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CENTENARY OF THE SAILING OF SIR JOHN FRANKLIN WITH THE *EREBUS* AND *TERROR*

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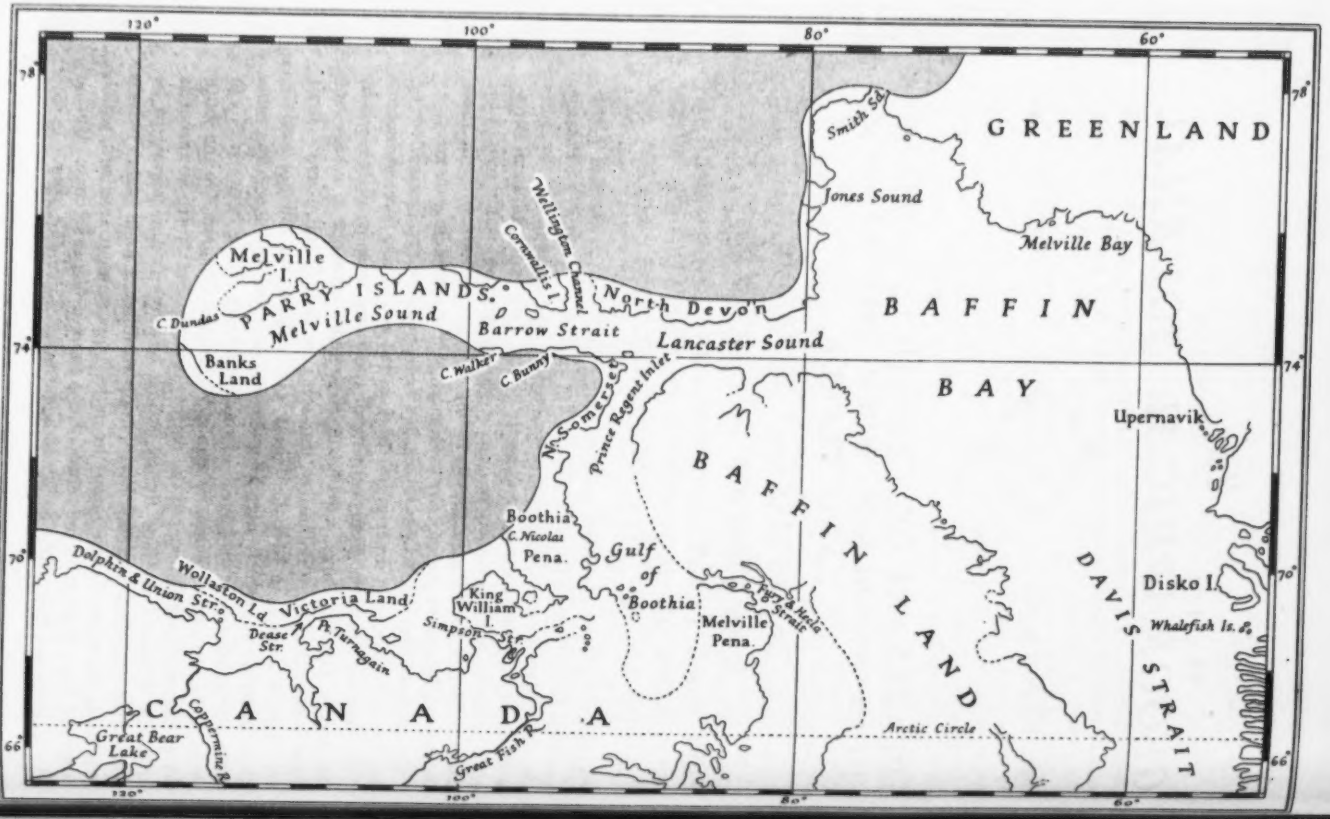
I. SIR JOHN FRANKLIN'S ORDERS CONSIDERED IN THE LIGHT OF GEOGRAPHICAL KNOWLEDGE WHEN HE SAILED, 1845. BY RICHARD J. CYRIAX

CAPTAIN SIR JOHN FRANKLIN, commanding H.M. Ships *Erebus* and *Terror*, sailed from Greenhithe on 19 May 1845 to seek a North West Passage. The alternative routes that he was instructed to take through the American Arctic archipelago were determined partly by the state of geographical knowledge, partly by the experiences of other explorers who had vainly sought the Passage. Hence brief consideration of the relevant portions of both these subjects is a necessary preliminary to discussion of the principal theme.

The geographical discoveries which had been made before Franklin sailed may, for convenience in description, be regarded as forming three groups:

The first or Northern group consists of the Parry Islands, discovered in 1819 by Sir Edward Parry, who demonstrated the existence of continuous channels extending from Baffin Bay, through Lancaster Sound, Barrow Strait and Melville Sound, to Melville Island. He noticed, but did not explore, several openings apparently stretching towards the north and separating some of the Parry Islands. The largest of these openings, lying between North Devon and Cornwallis Islands, he named Wellington Channel. On the south side of Barrow Strait he charted the entire north coast of North Somerset as far to the westward as Cape Bunny, which however is now known to be situated not on North Somerset itself but on an adjacent small island. About 40 miles to the west of Cape Bunny he noticed a prominent headland, which he named Cape Walker, in the centre of two short stretches of coast. During his voyage to and from Melville Island he observed no land on the south side


120°
100°
80°
60°
78°
74°
70°
66°
GREENLAND
Smith Sd.
Jones Sound
Melville Bay
BAFFIN
BAY
Lancaster Sound
North Devon
Wellington Channel
Cornwallis I.
Melville I.
PARRY ISLANDS
Melville Sound
C. Dundas
Barrow Strait
Banks Land
C. Walker
C. Bunny
Prince Regent Inlet
Somerset I.
Upernavik
BAFFIN LAND
Boothia
C. Nicolai
Pena.
Gulf of Boothia
Melville Pena.
Fury & Hecla Strait
DAVIS STRAIT
Disko I.
Whalefish Is.
Dolphin & Union Str.
Wollaston Ld.
Victoria Land
King William I.
Simpson Str.
Dease Str.
R. Turnagain
CANADA
Arctic Circle
Great Bear Lake
Coppermine R.
Great Fish R.

of Barrow Strait between the coast around Cape Walker and the north coast of Banks Land, which he saw in the distance from Melville Island. He was the only explorer who had been in the vicinity of Cape Walker when Franklin sailed.

The second or Southern group of discoveries consists of the north American coastline, from Bering Strait to the estuary of Back's Great Fish river, and of the lands lying to the north of and immediately opposite to the eastern end of this long coastline—Wollaston Land, Victoria Land, and King William Land, separated from the continent by Dolphin and Union Strait, Dease Strait, and Simpson Strait respectively. These lands, as known when Franklin sailed, lay between the 93rd and 116th meridians of west longitude. Between the latter meridian and Bering Strait only small islands had been discovered off the mainland. The continuity of Wollaston Land and Victoria Land had not been demonstrated, and their northern coasts had not been examined. The north coast of King William Land had been explored in 1830 by Sir James Clark Ross; it was believed to be a peninsula attached to Boothia, and the supposed northern and southern boundaries of the connecting isthmus were shown on the charts by means of dotted lines. James Clark Ross himself, after the explorations of Dease and Simpson in 1839, concluded that this isthmus did not exist and that King William Land was an island, but the correctness of his conclusion was not proved until 1854.

The third or Eastern group comprises the east coasts of North Somerset and Boothia, and Prince Regent Inlet with its southerly continuation, the Gulf of Boothia. The northern part of this area had been explored by Parry, and the southern part by Sir John Ross, but not exhaustively. No explorer had reached the southern end of the Gulf of Boothia, and hence its supposed boundaries were shown on the charts by means of dotted lines laid down in accordance with information obtained from Eskimos by Parry and Ross.[1] Fury and Hecla Strait, discovered by Parry in 1822, was believed to enter the Gulf of Boothia, but only Eskimo evidence to this effect had been obtained. Some geographers believed that this gulf communicated directly with Simpson Strait, and hence that Boothia was an island, but John Ross denied this; and the question whether a channel led to the westward into that strait from the Gulf of Boothia was a controversial one.[2] Bellot Strait had not been discovered, although its existence was suspected by James Clark Ross,[3] and it was not shown on the charts either as a supposed or as a possible strait.

The remaining lands and seas lying between Hudson Strait, Lancaster Sound, and Baffin Bay, need not be considered in the present connection.

If the three groups described above are now considered as a whole, it becomes apparent that what was required to complete the discovery of a

[1] Sir W. Edward Parry, 'Journal of a second voyage for the discovery of a North-West Passage,' London, 1824, chart opp. p. 198. Sir John Ross, 'Narrative of a second voyage in search of a North-West Passage,' London, 1835, chart opp. p. 258.

[2] Sir John Richardson and Sir James Clark Ross apparently believed that this channel existed; Sir John Franklin was uncertain. See *J. Roy. Geogr. Soc. London*, 6 (1836) 40, 44, 45, and Sir John Barrow, 'Voyages of discovery and research within the Arctic Regions,' London, 1846, pp. 515, 516, 517, 518, 529, 530.

[3] Sir F. Leopold McClintock, 'The voyage of the *Fox* in the Arctic Seas,' 5th edition, London, 1881, footnote on p. 153.

North West Passage when Franklin sailed was proof of the existence of continuous channels extending within the Arctic Circle from Davis Strait and Baffin Bay, and more particularly from Lancaster Sound and Barrow Strait, to any part of the American mainland lying between the estuary of the Great Fish river and Bering Strait. Whether this proof was obtained from the Atlantic or from the Pacific side was immaterial to the solution of the problem, but an attempt from the Pacific side was considered impracticable for ships sailing from Great Britain; first because the provisions and fuel consumed during the long voyage to Bering Strait round the Cape of Good Hope, or Cape Horn, could not be renewed where the principal work was to begin, secondly because the sudden change of climate from the Torrid to the Frigid Zone was expected to be inimical to the health of the officers and crews.[1]

Several channels offered themselves on the Atlantic side. One was Fury and Hecla Strait, but since ice had prevented Parry from sailing his ships through it, further attempts there were considered inexpedient. Jones Sound and Smith Sound, both branching out of the northern part of Baffin Bay, had not been explored, and hence offered very uncertain prospects. There remained Lancaster Sound, and this was the obvious gateway to the hoped for Passage. From that Sound, which was believed to be navigable every summer, three alternative routes were available, and these will now be considered.

The first was through Prince Regent Inlet and the Gulf of Boothia, but these channels were believed to offer poor prospects of success. Both Parry and John Ross had vainly sought a North West Passage through them, and whether channels led from them to the westward was still undecided, as has already been mentioned.

The second route from Lancaster Sound was through Barrow Strait, and then through one of the channels, preferably Wellington Channel, leading northwards between the Parry Islands.

Parry had observed, when passing the entrance to Wellington Channel in 1819 and 1820, that the channel itself appeared perfectly navigable. He saw no ice in it, and would have sought a North West Passage there himself if he had been unable to penetrate farther to the westward.[2] How far to the northward Wellington Channel extended was not known, but some geographers believed on theoretical grounds that it probably entered a comparatively open sea,[3] akin to the "Polynia" discovered by Baron Wrangell off the north coast of Siberia, and would present few obstacles to the accomplishment of a North West Passage by circumnavigation of the Parry Islands. But it was admitted that the adoption of this route would necessitate sailing hundreds of miles through an entirely unknown region and losing all the advantages to be derived from utilizing some of the other channels that had already been at least partly explored. Hence most authorities thought that Wellington Channel was not the route that should be attempted first.

The third and last route from Lancaster Sound lay through Barrow Strait

[1] Sir W. Edward Parry, 'Journal of a voyage for the discovery of a North-West Passage,' London, 1821, pp. 299, 300.

[2] Sir W. Edward Parry, *op. cit.*, 1821, pp. 51, 52, 53, 265.

[3] Preface by Colonel E. Sabine to 'Narrative of an expedition to the Polar Sea,' F. von Wrangel, English edition, London, 1840, pp. iii–xi.

and thence to the south-west through Melville Sound. All Parry's attempts in 1819 and 1820 to penetrate directly to the westward from Melville Sound had been foiled by extremely heavy ice at Cape Dundas, on the south-west coast of Melville Island. This ice drifted slowly towards the south-east through a strait (now called McClure Strait), bounded on the north by Melville Island and on the south by the north coast of Banks Land, which Parry saw in the distance but did not visit. After several abortive attempts to pass his ships, the *Hecla* and *Griper*, through this ice, Parry declared in August 1820: "It now became evident, from the combined experience of this and the preceding year, that there was something peculiar about the south-west extremity of Melville Island, which made the icy sea there extremely unfavourable to navigation, and which seemed likely to bid defiance to all our efforts to proceed much farther to the westward in this parallel of latitude. We had arrived off it on the 17th of September, 1819, after long and heavy gales from the north-westward, by which alone the ice is ever opened on this coast, and found it, in unusually heavy and extensive fields, completely closing in with the land, a mile or two to the eastward of where we were now lying. We again arrived here in the early part of August . . . the same obstruction presented itself as before; nor did there appear, from our late experience, a reasonable ground of hope, that any fortuitous circumstance, such as an alteration in winds or currents, was likely to remove the formidable impediments which we had now to encounter. The increased dimensions of the ice hereabouts would not alone have created an insurmountable difficulty in the navigation, but that it was very naturally accompanied by a degree of closeness which seldom or never admitted an open space of clear water of sufficient size for a ship, or even a boat, to sail in." The ice which he saw to the west and south-west near Cape Dundas in August 1820, he described as being "as solid and compact, to all appearance, as so much land," and his final conclusion was that there seemed "little or nothing to hope for from any further attempts to prosecute the main object of the voyage in this place." [1]

But the northern group of discoveries, extending from Lancaster Sound to Melville Island, projected about 300 miles farther to the westward than the southern group, the American coastline from the estuary of the Great Fish river to Bering Strait. An unexplored quadrilateral intervened, the north-west corner being formed by Banks Land, the north-east by Cape Walker, the south-west by Wollaston Land, and the south-east by King William Land. The distance from Cape Walker to the eastern end of Banks Land, as shown on Parry's chart,[2] was about 200 miles, and from Cape Walker to King William Land about 360 miles, so that the whole unexplored region had an area of about 70,000 square miles. If ships, sailing southwards and westwards from Barrow Strait or Melville Sound, could pass through this unexplored quadrilateral to the American mainland, the problem of the North West Passage would be solved. Since Parry had found that the ice increased both in extent

[1] Sir W. Edward Parry, *op. cit.*, 1821, pp. 241, 250, 297, and Official Report in Parliamentary Paper, "Instructions to Captain Sir John Franklin," London, 1848, p. 43.

[2] The position assigned to the supposed eastern extremity of Banks Land varied on different charts. According to Parry's chart, which was the original one and hence has been accepted as authoritative, Banks Land extended to the eastward as far as longitude 110° W., *op. cit.*, 1821, map opp. p. 29.

and in closeness from Barrow Strait to Melville Island,[1] an attempt to sail southwards and westwards from near Cape Walker seemed more likely to succeed than one made farther to the west.

The first authority who advocated an attempt in this direction appears to have been Sir John Barrow, the Second Secretary to the Admiralty. The R.G.S., during his Presidency, appointed a Committee on 8 February 1836 to receive and examine communications on a North West Passage, and he himself contributed an article. After some preliminary remarks, he pointed out that it had been practically ascertained that the current setting past Icy Cape on the American coast to the north of Bering Strait entered the Atlantic through Fury and Hecla Strait, after passing along the northern coast of America; but he did not explain the grounds on which this conclusion was based. He then remarked that the voyages hitherto undertaken in search of a North West Passage had necessarily been of an experimental character, and the method adopted, a very natural one, had been to cling to some shore. But this was a mistaken policy, for the consequence had been that ships had remained frozen up in harbours when the ice outside was navigable. He continued: "The plan then should be, to keep in the open sea, whether covered with ice or not—covered, I believe, it never is—the ice may move about in *fields* or separate masses, according to the direction and strength of the wind, but there will always be open water. But . . . where is this open sea to be found? In my view of the case, it has been already found, and I will briefly point it out.

"We know, from the observations of Franklin and Richardson" (whose discoveries in 1821 and 1826 along the North American coast extended from Return Reef in the west to Point Turnagain, in Dease Strait, in the east), "that from the several points they visited along the northern coast of America no land was visible to the northward, and that they found the sea mostly free from ice, except in two or three places, where there were small detached masses, offering no obstruction to the navigation even of the Eskimaux canoes. We further know that in the year 1822, two Russian corvettes passed thirty or forty miles beyond Icy Cape, found an open sea with no ice to obstruct navigation, and a current setting to the eastward. Since then Captain Beechey's master doubled Icy Cape in the ship's longboat" (a boat from H.M.S. *Blossom*, in 1826) "and proceeded seven degrees of longitude to the eastward without any obstruction; no land was seen by him to the northward. . . . Captain James Ross, in his progress on the western coast of the land which has been called Boothia, saw no land whatever to the westward; and his idea is, that the same coast trended up northerly to Cape Walker in Barrow's Strait, where Parry describes a large opening.

"We may therefore, I think, safely infer that between the coast of America and the northern islands (that of Melville and others) there is a broad open sea—open enough for a ship of war to make her way through it. The result of four voyages has shown that no difficulty exists in the navigation of Lancaster Sound and Barrow's Strait; that out of the latter are several large openings on the southern side, through one of which, perhaps the nearest or that about Cape Walker, a ship would easily pass into that part of the Arctic Sea

[1] Sir W. Edward Parry, *op. cit.*, 1821, p. 297.

which I have pointed out; and in such case, I do not think it would be presuming too much to express a hope, that the passage would be accomplished—and perhaps in one year." [1]

When Barrow expressed these opinions in 1836, only parts of the coastline between Bering Strait and the estuary of the Great Fish river had been examined, but during the next three years the labours of Dease and Simpson, whose own researches connected the discoveries of earlier explorers, resulted in an almost complete survey.

Barrow's suggestion was not adopted when it was first made, and he repeated it about eight years later. In December 1844 he handed to the First Lord of the Admiralty, then Lord Haddington, a document entitled "Proposal for an attempt to complete the discovery of a North-West Passage." [2] In this, he reaffirmed his belief in a comparatively open sea lying along the American mainland from Bering Strait to King William Land and extending through the unexplored quadrilateral to Melville Sound. He apparently believed that Banks Land, if it existed, Wollaston Land and Victoria Land were only small islands, and that a ship sailing to the south-west from Cape Walker and keeping midway between the supposed Banks Land and the American coast, would encounter little difficulty in navigating 900 miles in an open sea, and hence in passing through a North West Passage. That Barrow believed in a Polar Sea which might be partly, but was never wholly, covered by ice, and that the secret of successfully navigating it was to avoid sailing along a coast, is clear from his remarks which have already been quoted.

His suggestions led to the despatch of the Franklin expedition, but were first submitted by Lord Haddington to Franklin, Parry, and James Clark Ross. They all agreed that an attempt should first be made to the southward and westward from Cape Walker. But Franklin did not subscribe to all Barrow's opinions. He believed that much land lay between Banks Land and Wollaston Land,[3] and that the greatest obstruction from ice would be encountered between the 95th and 125th meridians of west longitude,[4] that is to say, between Cape Bunny and a point about 250 miles to the westward of the eastern end of Banks Land, as shown on Parry's chart. Ross thought that the heavy ice discovered by Parry near Cape Dundas stretched at least 200 miles towards the south-east, and would prove the chief obstacle to sailing southwards and westwards from Cape Walker; and some of his remarks, made a few years after Franklin had sailed, show that he finally concluded that this obstacle had in fact proved insurmountable. He then stated that the *Erebus* and *Terror* were probably beset in ice or locked in a harbour approximately in the centre of the unexplored quadrilateral, and would have to be abandoned. Indeed, there is reason to believe that he at least suspected that this stream of

[1] *J. Roy. Geogr. Soc. London*, 6 (1836) 34–37.

[2] Quoted by C. R. Weld, 'Arctic expeditions,' London, 1850, pp. 34–37. See also Barrow's letter to the First Lord of the Admiralty, quoted from the original in the Admiralty Records, Public Record Office, by R. J. Cyriax in 'Sir John Franklin's last Arctic expedition,' London, 1939, pp. 21, 22.

[3] Letter to Parry, quoted by the Reverend E. Parry in 'Memoirs of Rear-Admiral Sir W. Edward Parry,' 5th edition, London, 1858, p. 280.

[4] Official Report to the First Lord, 24/1/45, Admiralty Records, Public Record Office, 'Arctic expeditions,' 1845–48. Quoted by R. J. Cyriax, *op. cit.*, 1939, pp. 24, 25.

ice passed to the south-east through Melville Sound as far as the north-west coast of King William Land, where he himself had seen not an open sea but one that was choked with extremely heavy masses of ice.[1]

Moreover, both he and Franklin, in their official reports to the First Lord, recommended that if sailing to the south-west from Cape Walker proved impracticable, an attempt should be made to seek a passage through Wellington Channel,[2] and of this suggestion Barrow disapproved.[3]

Lastly, neither Franklin nor Ross believed that a North West Passage could be completed in one year unless quite exceptionally favourable conditions prevailed.

Franklin's orders were based upon the foregoing considerations. He was instructed to reach Lancaster Sound as quickly as possible and then try to reach Bering Strait in accordance with the following directions, which I quote in full:

"Lancaster Sound, and its continuation through Barrow's Strait, having been four times navigated without any impediment by Sir Edward Parry, and since frequently by whaling ships, will probably be found without any obstacles from ice or islands; and Sir Edward Parry having also proceeded from the latter in a straight course to Melville Island and returned without experiencing any, or very little, difficulty, it is hoped that the remaining portion of the passage, about 900 miles, to Bhering's Strait may also be found equally free from obstruction; and in proceeding to the westward, therefore, you will not stop to examine any openings either to the northward or southward in that Strait, but continue to push to the westward without loss of time, in the latitude of about 74¼°, till you have reached the longitude of that portion of land on which Cape Walker is situated, or about 98° west. From that point we desire that every effort be used to endeavour to penetrate to the southward and westward in a course as direct towards Bhering's Strait as the position and extent of the ice, or the existence of land, at present unknown, may admit.

"We direct you to this particular part of the Polar Sea as affording the best prospect of accomplishing the passage to the Pacific, in consequence of the unusual magnitude and apparently fixed state of the barrier of ice observed by the 'Hecla' and 'Griper,' in the year 1820, off Cape Dundas, the south-western extremity of Melville Island; and we, therefore, consider that loss of time would be incurred in renewing the attempt in that direction; but should your progress in the direction before ordered be arrested by ice of a permanent appearance, and that when passing the mouth of the Strait, between Devon and Cornwallis Islands"—this Strait was Wellington Channel—"you had observed that it was open and clear of ice; we desire that you will duly consider, with reference to the time already consumed, as well as to the

[1] Official Report to the First Lord, Admiralty Records, Public Record Office, 'Arctic expeditions,' 1845–48; and later official report in Parliamentary Paper, 'Instructions to Captain Sir John Franklin,' London, 1848, p. 45. See also R. J. Cyriax, "Sir James Clark Ross and the Franklin Expedition," in *Polar Record*, 24 (1942) 528–40.

[2] Official Reports to the First Lord, *loc. cit.*

[3] Memorandum by Sir John Barrow, Parliamentary Paper, *op. cit.*, 1848, pp. 72, 73. See also letter from his son, Mr. John Barrow, in *Nautical Magazine*, London, November 1851.

symptoms of a late or early close of the season, whether that channel might not offer a more practicable outlet from the Archipelago, and a more ready access to the open sea, where there would be neither islands nor banks to arrest and fix the floating masses of ice; and if you should have advanced too far to the south-westward to render it expedient to adopt this new course before the end of the present season, and if, therefore, you should have determined to winter in that neighbourhood, it will be a matter for your mature deliberation whether in the ensuing season you would proceed by the above-mentioned Strait, or whether you would persevere to the south-westward, according to the former directions." [1]

It will be noticed that Franklin was to pass as quickly as possible through Lancaster Sound and Barrow Strait, and was to steer to the southward and westward when he had reached, to quote the original text, "the longitude of that portion of land on which Cape Walker is situated, or about 98° west." These directions with respect to Cape Walker and the adjacent land, were somewhat vaguely worded, and were no doubt intended to be so, for the following reasons: Parry, the only explorer who had been near Cape Walker, sighted it at a distance of about 14 miles on 24 August 1819; he believed it to lie in latitude 74° 7′ N., longitude 97° 42′ W., but did not land on it. He observed a line of coast stretching from it towards the west as far as longitude 98° 20′ W., and he noticed also, a few miles to the south of it but not obviously connected with it, the appearance of land running in an easterly direction towards Cape Bunny, as far as longitude 97° 20′ W. His chart thus showed land on both sides of Cape Walker; this land, as a whole, occupied 1 degree of longitude (corresponding to about 17 miles in that latitude) and was crossed by the 98th meridian.[2]

Franklin himself, when he sailed, expected to steer southwards and westwards between Cape Walker and Banks Land, that is to say, from some point to the west of Cape Walker,[3] and most of the authorities believed, when the search for him began, that he had actually done so. Indeed, James Clark Ross, until he himself had discovered Peel Sound, on the east side of Cape Walker, during his sledge-journey in 1849, apparently believed that Cape Walker and Cape Nicolai, on the west coast of Boothia, were probably joined by a continuous coastline,[4] and hence that Melville Sound afforded the only channel through which ships could sail south and west from Cape Walker.

On the other hand, Parry declared that attempts to penetrate towards the south from the channels stretching from Baffin Bay to Melville Island were most likely to succeed if made immediately to the east of Cape Walker,[5] that is to say, between that cape and Cape Bunny, so that he must have suspected the existence of Peel Sound. This opinion of Parry's appears to explain why Franklin was ordered to steer southward and westward when he had reached, again to quote the exact words, "the longitude of that portion of land on

[1] Parliamentary Paper, *op. cit.*, 1848, pp. 3, 4.

[2] Sir W. Edward Parry, *op. cit.*, 1821, p. 56 and map opp. p. 29. The land stretching from the south side of Cape Walker towards Cape Bunny is clearly shown on Parry's charts, but not on all charts.

[3] Official Report to the First Lord, *loc. cit.*

[4] Sir John Ross, *op. cit.*, 1835, p. 560.

[5] Sir W. Edward Parry, *op. cit.*, 1821, p. 264.

which Cape Walker is situated, or about 98° west." He was thus free to change his course either on the east or on the west side of Cape Walker, provided only that he did so when he had reached the longitude of "about 98° west." The course which he is believed to have taken in 1846, namely, down Peel Sound, the entrance to which from Barrow Strait lies between Capes Walker and Bunny, was thus in strict conformity with his orders.

It is worthy of mention that the paragraph directing Franklin to seek a passage through Wellington Channel, if unable to penetrate to the south and west from the vicinity of Cape Walker, appears as a marginal entry on the original document in the Admiralty Records.[1] A clerical error may conceivably have been responsible for the omission of this paragraph when the orders were drafted; but it seems equally probable that Franklin, who was no doubt consulted about his orders, himself suggested his being given permission to adopt, if necessary, the alternative route that he himself, as well as James Clark Ross, had recommended to the First Lord, and that his suggestion was adopted.

The routes which Franklin was ordered to take were based upon the best information then obtainable, but knowledge acquired since has shown that the ice between Melville Island and Banks Land is not always impenetrable, contrary to Parry's belief. His conclusion was however considered unassailable a century ago, and hence Franklin's orders forbade an attempt to steer south and west from Melville Island, with the result that he was restricted from seeking a passage much to the westward of Cape Walker. If foiled near that cape, he was therefore compelled to enter Wellington Channel, which, in view of Parry's opinions, appeared to offer prospects of success only slightly inferior to those afforded by crossing Melville Sound from near Cape Walker.

It remains only to describe very briefly the route which Franklin took. His ships were accompanied by a transport, the *Barretto Junior*, to the Whalefish Islands, from which he sailed on July 12. At the end of that month the *Erebus* and *Terror* were seen for the last time by strangers, other than Eskimos, from a British whaling ship, the *Enterprise* (not the *Prince of Wales*, as is frequently stated)[2] in the upper part of Baffin Bay. They were moored to an iceberg, and Franklin was awaiting an opportunity to cross the bay to Lancaster Sound.

Probably during the next fortnight, Franklin passed through Lancaster Sound and entered Barrow Strait. How far he advanced to the westward is unknown, but he must for some reason have been prevented from steering to the south and west from near Cape Walker, for he entered Wellington Channel. After sailing through it as far as the latitude of 77° N., he returned to Barrow Strait by way of Crozier Strait, which separates Cornwallis Island from Bathurst Land and has apparently never been visited since by any explorer. He then wintered (1845–46) at Beechey Island.

In 1846 he is believed to have sailed through Peel Sound and Franklin Strait, until, on September 12, his ships were beset in the upper part of Victoria Strait in heavy ice which had come from Melville Sound through McClintock Channel. The second winter (1846–47) was passed in this ice. Franklin had now proved the existence of a continuous channel from Barrow

[1] Public Record Office, 'Arctic expeditions,' 1845–48.
[2] R. J. Cyriax, *op. cit.*, 1939, pp. 64–68.

Strait to the upper part of Victoria Strait; all that was now required to complete the discovery of a North West Passage was proof that Victoria Strait joined Simpson Strait; and in May 1847 he sent to King William Land from the *Erebus* a small party commanded by Lieutenant Gore, whose objective is believed to have been the obtaining of the requisite proof.[1] Neither the extent of Gore's explorations, nor the duration of his absence, is known, but there is no reason to doubt that he accomplished his task and returned to the *Erebus* with the news that the expedition's principal purpose had been achieved.

On 11 June 1847, less than three weeks after Gore's departure from the *Erebus*, Franklin died, and since his grave has not been found on King William Land, he was presumably buried beneath the ice in Victoria Strait. Whether he was still alive when Gore returned must remain an open question, for the date of Gore's arrival on board is not known.

With Franklin's death, the command devolved upon Captain Francis Rawdon Moira Crozier, of the *Terror*. The ships remained beset and were slowly carried towards Simpson Strait by the southerly drift down Victoria Strait.[2] During the next winter (1847–48), which was passed in the ice, a severe outbreak of scurvy seems to have made its appearance and to have caused many deaths, particularly among the officers. The expedition had been provisioned for three years, approximately until August 1848, and hence Crozier was compelled to abandon the ships at the end of the third winter. He and all his officers and men landed at Point Victory, and on 25 April 1848, he and his second-in-command, Captain James Fitzjames, wrote on one of the records deposited by Gore in 1847, the last message that the civilized world has received from the Franklin expedition. Only one hundred and five officers and men were still living, nine officers and fifteen men having died.

Crozier intended to travel along the west and south coasts of King William Land and then up the Great Fish river to the nearest post of the Hudson's Bay Company—Fort Resolution. He and all his officers and men fell by the way, and the terrible disaster which overtook them has been only too clearly revealed by the graves, skeletons, and relics, which have since been found to mark the whole line of march along the shore of King William Land from Point Victory to near Point Hall, and on the mainland near the mouth of the Great Fish river.

One of the abandoned ships is believed to have foundered in Victoria Strait. The other seems to have drifted to O'Reilly Island, where she was found and plundered by Eskimos before she too sank.

According to some Eskimo reports, a few men, who had apparently returned to the ships after the disastrous retreat had begun, survived until the spring of 1849 on board the ship that sank near O'Reilly Island.[3] All the others probably died during the summer or early autumn of 1848, and there seem to be no valid grounds for the supposition, formerly current, that some of the

[1] Sir F. Leopold McClintock, *op. cit.*, 1881, pp. 246, 257.

[2] *Ibid.*, pp. 244 *et seq.*

[3] J. E. Nourse, 'Narrative of the second Arctic expedition made by C. F. Hall,' Washington, 1879, pp. 404, 405, 418. W. H. Gilder, 'Schwatka's search,' London, 1881, pp. 78, 79.

missing men were able to prolong their lives for several years, either by their own efforts or by taking refuge with Eskimos.[1]

Many matters connected with the lost expedition remain obscure, but one at least is clear. Some of the officers and men, marching towards the Great Fish river after abandoning their ships, reached Simpson Strait by way of the west coast of King William Land, and thereby proved the existence of a North-West Passage. The Franklin expedition is thus definitely known to have discovered a Passage in 1848, and in all probability Gore had already done so in 1847. The Franklin expedition found what it had been sent to find.

II. THE NORTH WEST PASSAGE SINCE THE LAST FRANKLIN EXPEDITION. BY J. M. WORDIE

Dr. Cyriax in his comments on Sir John Franklin's Orders has shown how large a blank there was on the map in 1845, and has named it the "unexplored quadrilateral." The exploration of this extensive blank area was the first step both in finding Franklin and in discovering the Passage.[2]

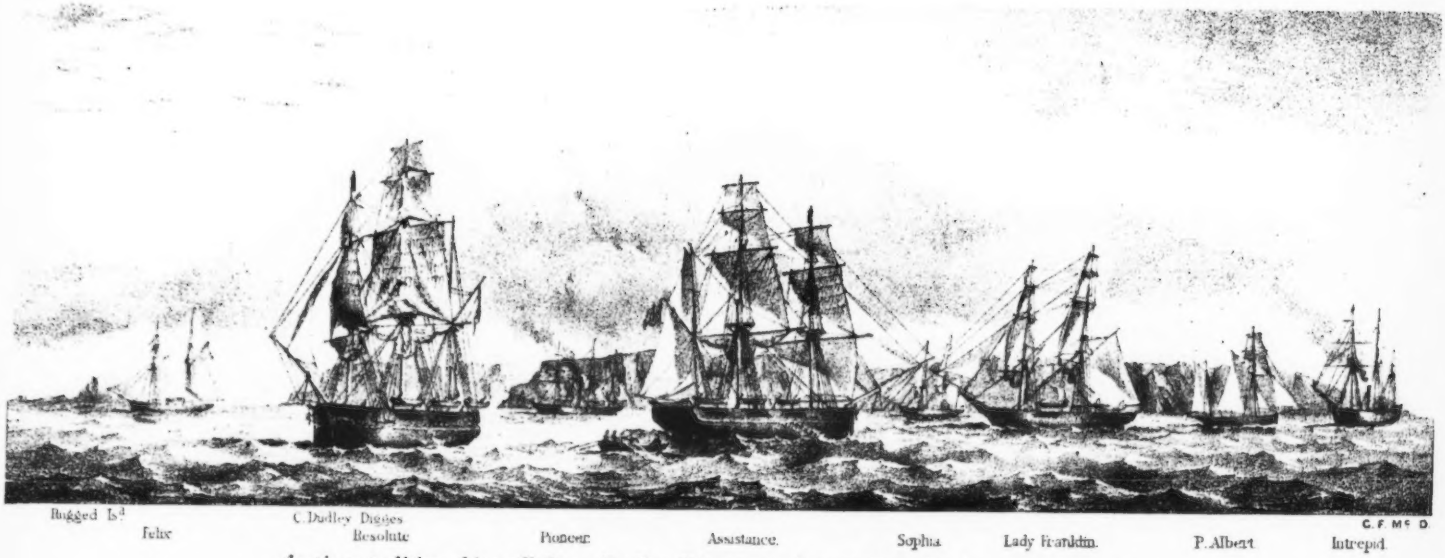
J. C. Ross 1848–49

The story begins with the Franklin Relief Expedition sent out in 1848 under Sir James Clark Ross in the *Enterprise* and the *Investigator*. The plan was a sound one and allowed for an exhaustive exploration of the quadrilateral, but the ships were held up in Melville Bay till late in the season, and in what was apparently an unusually bad ice year did not reach Pond Inlet, near the entrance to Lancaster Sound, till August 23. Ross, with the two ships in company, then sailed westwards along the south side of Lancaster Sound from Possession Bay on Bylot Island to Cape York, at the eastern side of the mouth of Prince Regent Inlet. He had had orders which contemplated separation of the ships and that one of them should winter at Melville Island or even at Banks Island. He hoped to push on along the north coast of Somerset Island to Cape Rennell, but ice barred the way, and on September 11 the ships were frozen in and forced to winter at Port Leopold at the north-east corner of Somerset Island. It was a good centre, however, less than 70 miles from Beechey Island, where Franklin, as was learnt two years later, had wintered in 1845–46, and not much more from the mouth of Peel Sound down which the *Erebus* and *Terror* must have sailed in 1846. Ross did as much as he could, and in the spring of 1849 sledged along the north and west coasts of Somerset Island. It is worth noting that Leopold McClintock was with Ross on this journey and that this was his first experience of sledging in which he was later to become a master. The journey at that time was a record one of over 500 miles in thirty-nine days, but only a short portion, 150 miles, of the

[1] R. J. Cyriax, "Captain Hall and the so-called survivors of the Franklin Expedition," in *Polar Record*, 28 (1944) 170–85.

[2] In the first part, by Dr. Cyriax, the spelling of place-names given was that in use in 1845. In this part the spelling has been brought into line with the modern usage of the Canadian Geographic Board.

Sir John Franklin. Lithograph by Negelen after the painting by J. H. Maguire



Arctic expedition ships off Cape Dudley Digges, north-west Greenland, 14 August 1850

east side of Peel Sound was examined, and Franklin had not apparently left any records. It should be added that Franklin had no instructions to leave records except in bottles or copper cylinders in the sea north of 65° N.

The two ships broke out of winter quarters on 28 August 1849. Ross planned to hunt westwards along the north side of Lancaster Sound and Barrow Strait, and had he succeeded he would probably have found the traces of Franklin's winter quarters at Beechey Island. Unfortunately the ships had broken out very late and there was also fixed land-ice along the south coast of Devon Island. The moving pack drove round the ships, and they drifted for twenty-four days eastwards out of Lancaster Sound into Baffin Bay. They were not free till September 24 and 25, and considering their position at this late date there was no other reasonable course open to Ross but to return home.

The results were disappointing, but it seems evident that Ross made no mistakes and was simply unlucky. Ross's belief that Franklin would be found approximately in the centre of the unexplored, quadrilateral in 73° N., 105° W. is of interest. Later search expeditions did not take this view, and Ross's conclusion was ignored.

The year 1848 was probably the last in which Franklin survivors might have been found. The *Erebus* and *Terror*, as became known later, were abandoned in April 1848 in Victoria Strait, the southward extension of Peel Sound and Franklin Strait, and Crozier and the hundred odd survivors then went south by King William Island towards Back's Fish River. Had Crozier waited till later in the season and had he trusted to small boats and directed his route northward to the whaling grounds of Prince Regent Inlet, he would in all probability have fallen in with Ross's ships in the late autumn of 1848. Ross of all the early searchers, though unaware of it, was nearest to the Franklin survivors. Moreover he had explored part of Peel Sound, an important discovery which might have led to an earlier knowledge of Franklin's fate, for it proved to have been the route of Franklin's North West Passage.

Austin 1850–51; *Kennedy* 1851–52; *Belcher* 1852–54

Ross was back home in 1849, too late for anything more to be done that year. Sir John Franklin had been absent for over four years. The country was roused and the year 1850, in addition to parties proceeding overland from Arctic Canada, saw no less than fourteen ships employed in the search. Most interest from the point of view of the North West Passage attaches to the long voyages of the *Enterprise* and *Investigator*, this time under Collinson and McClure, who sailed in 1850 to the western end of the Passage via Bering Strait. Before commenting on these two remarkable voyages, some account is necessary of the official search parties which penetrated to Lancaster Sound from the east, first in 1850–51 and again in 1852–54.

For reasons which need not be debated, later searches became largely concentrated among the islands on the north side of Lancaster Sound and Barrow Strait, but in 1850–51 an attempt was made, following Franklin's Instructions, to make Cape Walker, west of Peel Sound, a starting point for searches to the south and west. Austin and Ommanney in the *Resolute* and *Assistance* with the steam tenders *Pioneer* and *Intrepid* wintered in the pack

near Griffith Island, and, in the spring of 1851, an extensive sledging programme was carried out, much of it from Cape Walker. Cape Walker itself was found to be on an island, and the large mass of land to the south was named Prince of Wales Land. A party went some distance down the east side, that is along the west side of Peel Sound, and Ommanney and Osborn went down the west coast of Prince of Wales Land, where they noted the heavy unnavigable ice to the west. In effect, an east-to-west strip of about 100 miles in breadth was explored on the south side of Barrow Strait. No Franklin records were found, as none had apparently been left, and all four ships returned home in the autumn of 1851.

Other ships which went in from the east in 1850, the *Lady Franklin* and *Sophia* under a whaling skipper Captain Penny, the *Felix* under the veteran Sir John Ross, and the *Advance* and *Rescue* from America under de Haven were all equally unsuccessful, most of them sailing over much the same ground. The one which came nearest to being on the right track at this date was the *Prince Albert*, sent out under Forsyth by Lady Franklin to Prince Regent Inlet. The voyage itself was disappointing, and the ship returned the same season after reaching no farther than the mouth of Prince Regent Inlet. It led however to further developments. Lady Franklin was far from satisfied, and the *Prince Albert* was sent out again in 1851, in the same direction but this time under Kennedy with the Frenchman Lieut. Bellot as second in command, with orders to explore to the south of Somerset Island. The *Prince Albert* wintered in 1851–52 at Batty Bay south of Port Leopold and Kennedy and Bellot sledged as far south as Bellot Strait, which they discovered, and then westward across Peel Sound to Prince of Wales Island. According to Sir Clements Markham they should, following their orders, have travelled south beyond Bellot Strait. Kennedy however thought that Peel Sound was not a through route but merely a pocket on the south side of Barrow Strait and that Franklin must therefore have taken a channel farther west.

The official search for Franklin did not cease after Austin's return in 1851 and there was no word moreover of either the *Enterprise* or the *Investigator*. A fresh expedition from the east was accordingly sent out in 1852 under Sir Edward Belcher in the *Assistance* and Kellett in the *Resolute*, with the steam tenders *Pioneer* and *Intrepid*, the latter under McClintock. The *Resolute* and *Intrepid* wintered at Dealy Island near Winter Harbour, while Belcher in the *Assistance* with the *Pioneer* wintered up Wellington Channel. The *North Star* stood by as a depot ship at Beechey Island. The sledge explorations in the following spring were unfortunately directed entirely to lands north of Barrow Strait, but included some remarkable journeys, among them Mecham's sledging record and McClintock's great effort to the north point of Prince Patrick Island. Nothing was found anywhere which bore on the fate of Franklin, and nothing which helped towards a North West Passage.

Collinson 1850–55 and McClure 1850–54

I have referred above to the voyages of the *Enterprise* and *Investigator* under Collinson and McClure, and used the word "remarkable." No other voyage of the Franklin search expeditions can rival them in length of Arctic service or in the amount of ground covered for the first time by large ships. To them

also belongs credit for completing the discovery of two possible North West Passages.

The two ships, Collinson in the *Enterprise* being in command of the expedition, set sail from Plymouth on 20 January 1850, passed through the Straits of Magellan in April, and reached the Sandwich Islands at the end of June. The *Enterprise* arrived a few days before the *Investigator*, and went ahead, the plan being that the two ships should rendezvous north of Bering Strait at Point Hope or Cape Lisburne, or at Wainwright Inlet still farther north and only about 70 miles short of Point Barrow. Collinson took the traditional sailing-ship route from the Sandwich Islands north-westwards on the Asiatic side. McClure in the *Investigator* had a slower ship, and, on being advised at the Sandwich Islands by letter from Collinson that Captain Kellett of the *Herald*, then on duty in Bering Strait, recommended a less-known but shorter track through the Aleutian Islands, took a sporting chance on the new route. The chance came off, and the *Investigator* drew ahead of the *Enterprise*. McClure met Moore in the *Plover* a little south of Cape Lisburne, and proceeding northwards on July 31 fell in about 20–30 miles north of the cape with the *Herald* commanded by Captain Kellett. The intention had been that the *Enterprise*, being almost certain to be first at Cape Lisburne, should await the *Investigator*. McClure now learnt from Kellett that there had been no sign as yet of the *Enterprise*. He appears to have then taken the view that the *Enterprise* had already arrived and deserted her consort. McClure, although it was still early in the navigable season, and despite contrary advice from Kellett, who was his superior officer, insisted on at once proceeding alone from Cape Lisburne. The events have been set out by Dr. Armstrong, Surgeon of the *Investigator* in 'A personal narrative of the discovery of the North West Passage,' and by Sherard Osborn in 'The discovery of the North West Passage.' The reasons given are not convincing, and the story is not improved by some of Armstrong's remarks. It has to be told in some detail as the consequences of McClure's haste in snatching the chance of an independent command were considerable. Armstrong writes that Kellett did not feel justified in detaining the *Investigator*, but goes on to say "The 'Herald' still kept ominously astern, which did not at all contribute to our comfort; for, it may now be confessed, we still feared that Captain Kellett would detain us . . . in the evening we saw the 'Herald' make all sail towards us, and rapidly closing from her superior sailing qualities, she made a signal recommending us to wait forty-eight hours for the 'Enterprize,' to which Captain McClure signalized in return, '*Important service. Cannot on my own responsibility!*' This not being clearly understood, Captain Kellett hailed from the poop, desiring us to repeat the signal, which was accordingly done." McClure, although aware that the *Investigator* had made one of the fastest passages on record from the Sandwich Islands, then made off alone on 1 August 1850, and rounded Point Barrow at midnight on the 5th.

Meantime Collinson in the *Enterprise* did not reach Cape Lisburne till August 13. Unfortunately he failed to meet either the *Plover* or the *Herald*, and found no records on shore. The rest of August was spent trying to find a way eastwards past Point Barrow, but heavy pack-ice proved a hindrance. Finally Collinson was back at Point Hope, near Cape Lisburne, on August 31,

and found a record on shore which made him aware that the *Investigator* had gone on. Soon after he met both the *Plover* and the *Herald*, made another attempt to find his consort, and finally, having been forbidden to winter in the open pack, was compelled to bear away south for the winter.

Next season Collinson was back at Cape Lisburne as early as the middle of July, and had rounded Point Barrow by the 25th. Navigation through the ice and the uncharted waters to the east was by no means easy. The next few weeks are a record of difficult and skilful navigation, and all who read the accounts both of Collinson's and of McClure's voyages cannot fail to admire the way in which the two captains handled their ships. On account of the various difficulties Cape Bathurst was not passed by the *Enterprise* till August 26; but after that there was a spell when everything seemed to go well. East of Cape Bathurst land was sighted to the north. Collinson then sailed across to the south-east corner of Banks Island and up Prince of Wales Strait without hindrance. On 31 August 1851 he was at the northern end, and separated only by about 60 miles of the ice-filled Melville Sound from Melville Island and waters navigated by Parry in 1819 and 1820. The north coast of Banks Island had in fact been first sighted by Parry from Melville Island. Collinson had therefore discovered a final link in a North West Passage.

This actual link, however, as Collinson found on reaching the north end of Prince of Wales Strait, had been already discovered in the previous year by McClure in the *Investigator*. McClure had rounded Point Barrow at midnight on 5 August 1850, had been off Pelly Island at the mouth of Mackenzie River on the 21st, and had reached Cape Bathurst on August 31. The time taken was a little less than that taken by Collinson in the same month in the year following. Land was then sighted away to the north, and with Melville Island as his objective McClure, who had up to now availed himself of land water along the American coast, decided to bear away and so discovered the southern part of Banks Island, called Baring Island at the time. The *Investigator* then sailed up the newly discovered Prince of Wales Strait, and wintered near the Princess Royal Islands. By these discoveries McClure, anticipating Collinson, had therefore found a ship route which would make a possible North West Passage, except that Parry did not think the pack-ice of Melville Sound was penetrable. In October 1850, from a height of 600 feet, McClure looked across to Melville Island, having sailed through 1200 miles of waters never before navigated in a large ship.

If one reads Sherard Osborn aright, McClure was more concerned in reaching Melville Island and making a North West Passage than in searching for Sir John Franklin. Next season he went back on his tracks and decided to try and reach Melville Island by sailing round the south coast of Banks Island westward to Cape Kellett and then up the west coast. There was a clear run from Prince of Wales Strait to Nelson Head on August 17, and Cape Kellett was passed on the 18th, after a stretch of open water of about 300 miles. The *Investigator* ran on for another 100 miles, but conditions changed near Norway Island in 74° N., and the next four weeks developed into an almost continuous struggle with ice and bad weather off the exposed north-west coast of Banks Island. This feat, which has never been repeated, must

have called for seamanship of a very high order. The northern points of Banks Island were rounded as late as September 22, and next day the ship finally came to rest in the appropriately named Mercy Bay.

The remainder of McClure's voyage is briefly told. Next summer, 1852, the *Investigator* failed to break out from Mercy Bay, but McClure had sledged across to Winter Harbour on Melville Island and left a record in the spring of 1852 at what is known as Parry Rock. Austin's searching squadron had already gone home in the autumn of 1851, and McClure had no knowledge of the later Belcher expedition, but in the autumn of 1852 Kellett, Belcher's second in command, reached Dealy Island with the *Resolute* and *Intrepid*, and Mecham, one of Kellett's officers, found McClure's record at Parry Rock. The discovery was made on 12 October 1852, when it was too late in the year to travel from Dealy Island to Banks Island. Lieut. Bedford Pim of the *Resolute* however was ordered to Banks Island as soon as the 1853 sledging season opened and on April 6 reached Mercy Bay. Many of the *Investigator's* men were by this time suffering from scurvy, and McClure had decided to divide his crew and that the weaker men should leave the ship and attempt to travel overland, some via Barrow Strait and others southwards to the American coast. These plans were now cancelled, the *Investigator* was abandoned under Kellett's orders, and the crew, after travelling on foot across the pack-ice of McClure Strait, were transferred in June 1853 to the *Resolute* and *Intrepid* at Dealy Island. These ships themselves failed to pass out of Barrow Strait in the autumn of 1853 and a further winter was necessary, the fourth for the *Investigator's* crew. In due course McClure and his men were transferred to the *North Star*, and reached England in September 1854.

The chances should have been that Collinson and McClure would meet when their ships were so close together near Banks Island in 1851. As a rule ships in Arctic waters if at all close generally fall in with each other, partly due to the high degree of visibility, but much more to the way in which ships tend to take the same route because it is the best. Collinson in August 1851 more or less repeated what McClure had done in 1850—slow progress along the coast from Point Barrow to Cape Bathurst followed by a rapid crossing to Banks Island and open water right on to the north end of Prince of Wales Strait. McClure knew nothing of Collinson's movements, but at the end of August 1851 Collinson knew that McClure had wintered at Princess Royal Islands in 1850–51, and he immediately set out to try and contact him. McClure had come south out of Prince of Wales Strait ten days before Collinson entered the strait going north. Collinson sailed back down Prince of Wales Strait and, like McClure two weeks earlier, followed the coast westward to Cape Kellett, and on September 6 found a record of McClure's left there on August 18. The ice beyond Cape Kellett appeared to be just breaking away from the coast and Collinson's ice masters advised him that McClure would have found the ice fast and must have followed the ice edge southwestwards away towards the mouth of the Mackenzie.

On September 7 Collinson accepted this view, gave up his attempt to find McClure, and sailed southwards and eastwards to carry on the Franklin search along. Winter quarters were selected at Walker Bay near the southern entrance to Prince of Wales Strait. Next spring sledge parties were sent off

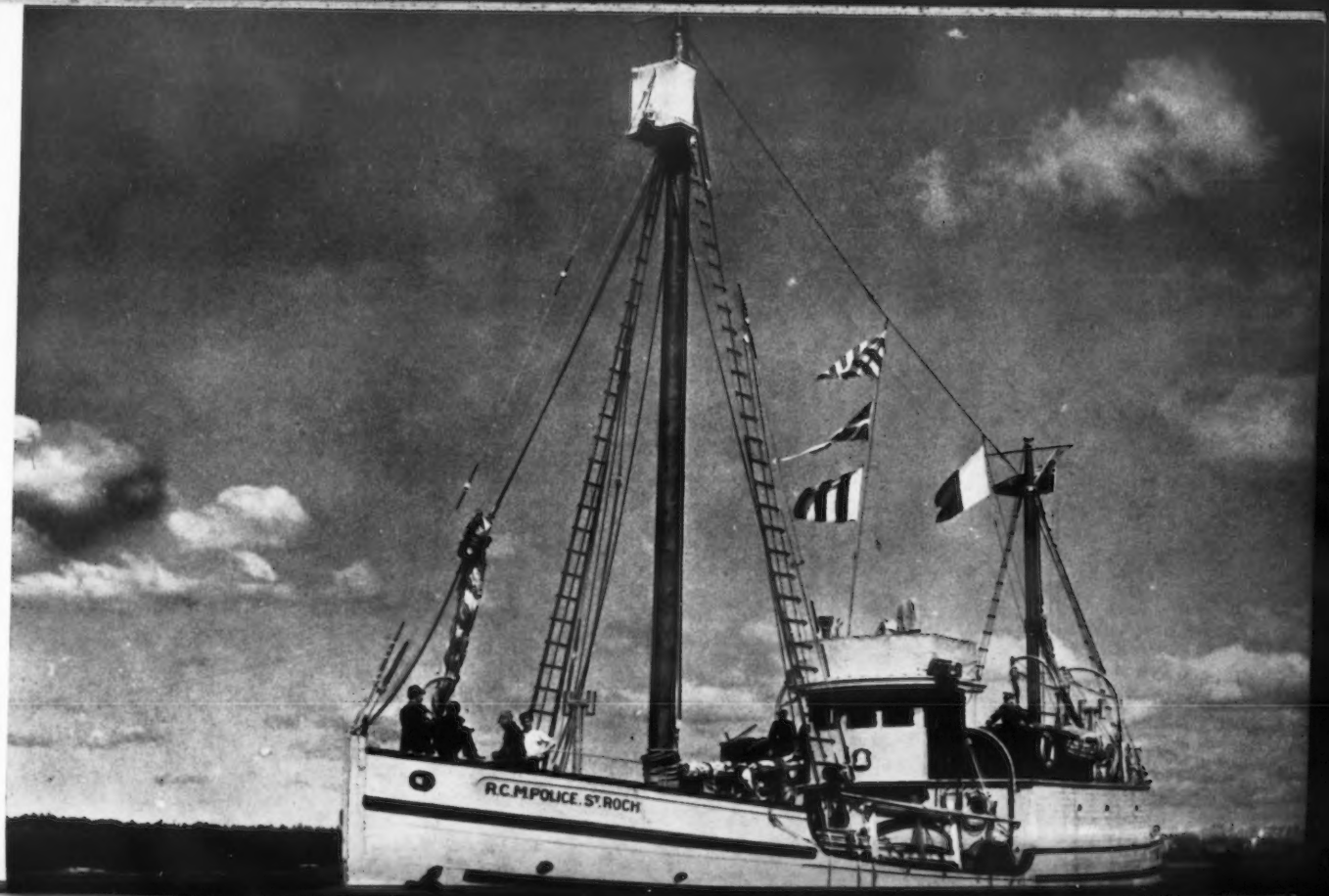
north and south from Walker Bay. That going northwards under Collinson himself with two sledges reached Peel Point at the north end of Prince of Wales Strait on 5 May 1852. Collinson then turned right and went south-eastwards to Glenelg Bay, while the other sledge under Parkes went north across the pack-ice to Melville Island, failed to reach Winter Harbour, but on May 16 left a record on shore in 74° 32′ N. Sledge tracks were seen near Hearne Point, and thought to have been left by natives. Actually they were the tracks left by McClure, who had been at Winter Harbour on April 28 and returned to Mercy Bay on May 11.

Collinson's ship was once more under way on 5 August 1852, and at the beginning of September the *Enterprise* entered Prince Albert Sound. Collinson was of course unaware that Kellett was about to winter at Dealy Island near Winter Harbour. He was determined to continue the search eastwards, and on 16 September 1852 he left Prince Albert Sound and took his ship through the narrow waters of Dolphin and Union Strait, across Coronation Gulf with its innumerable islands, and through Dease Strait to Cambridge Bay, at the south-east of Victoria Island, where he reached winter quarters on September 28. This was a magnificent piece of navigation by a large and cumbrous sailing ship in irregular and more or less uncharted waters. The *Enterprise* was now on the threshold of the region where Franklin's ships were abandoned in April 1848, but at the time this was still unknown. Collinson had moreover been preceded in this region by Dr. Rae in 1851, but only became aware of this when he reached Rae's farthest point and found his record. Collinson, like Rae, explored round the south-east part of Victoria Island, that is to say on the west side of Victoria Strait. The remains of Franklin's party were only 30 miles away to the eastward, but Collinson was unable to do more. He however found, on one of the Finlayson Islands near Cambridge Bay, what he thought might have been a fragment of one of Franklin's ships. He concluded that it could not have been left by Rae, but was either part of a companion hatch or the lintel post of an observatory; a special feature was a copper hasp for securing the latch of a door, marked with the Queen's mark, or, as we should say, a broad arrow. Collinson's surmise was correct. It is now known that the *Erebus* and *Terror* were abandoned in the north end of Victoria Strait, and that one of them drifted through Victoria Strait to O'Reilly Island, from where the "hatch" would drift westwards to the Finlayson Islands and Dease Strait. Collinson also met natives at Cambridge Bay, who did their best to indicate to him that a ship was held in the ice to the eastward. The expedition interpreter however was on board the *Investigator* with McClure, and this native report was never fully understood and acted on.

Collinson's ship had now been in commission for nearly four years. He was still unaware that Belcher and Kellett were in Barrow Strait. He appeared to be alone, and it was essential for the sake of the health of his crew to get back to temperate latitudes. Cambridge Bay was left on 10 August 1853, and Cape Bathurst passed on the return voyage westward on September 1. Wind and ice however became unfavourable. The *Enterprise* was in Camden Bay, west of Herschel Island, on September 14, but in the next few days the ice began to pack and held her in the bay, and by the end of the month it was clear

"Enterprise" and "Investigator" in winter quarters at Port Leopold, 1848–49. After the water-colour by Lieut. W. H. Browne

Melville Island from Banks Island. After the water-colour by Lieut. Gurney Cresswell



R.C.M.P. Patrol

that another winter would be necessary. The *Enterprise* finally broke out on 15 July 1854, passed Point Barrow on August 8, and, sailing via Hong Kong and the Cape of Good Hope, reached Sheerness on 17 May 1855.

It is difficult not to take sides. In reviewing the achievements of the *Enterprise* and *Investigator* Collinson himself says of McClure: "To him belongs the honour of first navigating the Arctic Sea along the American coast, and the discovery of the Prince of Wales Strait . . . neither of us have succeeded in the grand object which animated our endeavours; but he, being first in the field, has added greatly to our geographical knowledge." McClure gained great honour for his ship, but Collinson's brother, who edited the 'Journal of H.M.S. *Enterprise*,' states ". . . if he [McClure] had waited for his consort, not only would the North-west Passage have been discovered, but the remains of the Franklin Expedition would also have been found. For, if he had waited, it is reasonable to suppose that the two vessels would have proceeded together up the Prince of Wales Strait (as they did separately), and that in 1852 they would have gone together along the coast of America to the eastward (as the *Enterprise* did); and in the spring of 1853, having double the number of sledges, the E. side of Victoria Strait would have been examined as well as the W. side (which was all the *Enterprise* could do), and therefore the remains of the Franklin expedition . . . on the coast of King William's Land would have been discovered in 1853."

Readers to-day appear to support Collinson, and are disinclined to exonerate McClure. In 1855 however the popular verdict was the other way. A Committee of the House of Commons was appointed to consider whether Captain McClure should be paid an award. In due course it was decided to award £5000 to Captain McClure for the completion of a North West Passage, and £5000 to his officers and crew. There were dissentients however and Sir Roderick Murchison was of the opinion that Collinson, by taking his ship to Cambridge Bay had found a way leading direct to Peel Sound, through which Murchison thought the *Erebus* and *Terror* must have passed. In Murchison's view this was the only feasible Passage, and Collinson, by taking his ship as far east as he did, had done more than any other to find a route which might come into common use.

I have written about Collinson and McClure at some length, for they determined the routes not only of one but of two possible North West Passages. Between them they made the only important contributions to the problem of the Passage in the years 1850–54.

McClintock 1857–59

The autumn of 1854 marked the close of the Franklin search by ship so far as the British Government was concerned. The greater part of the quadrilateral, unexplored when Franklin sailed, had been examined. The Belcher expedition was at an end, and word had come from the North Pacific that Collinson had brought the *Enterprise* out of the ice and broken a silence of more than three years. Most important of all, Dr. Rae had reported having been told by Eskimos that many of Franklin's men had died near the mouth of Back's Fish River, and the Eskimo reports invariably said that all the white men were dead. The British public however was not entirely satisfied, and it

was clear that something more should be done to determine the nature of the disaster. The Franklin men were known to have died near King William Land, which Rae had now shown to be an island, but the area still remained unsearched. Rae had obtained only relics from the Eskimos. Lady Franklin strove in every possible way to get a final expedition sent out, and at last succeeded, choosing as leader Captain McClintock, who had already sought and sledged with J. C. Ross in 1848–49, under Austin in 1850–51, and under Belcher and Kellett in 1852–54. The area of search was now restricted to the region which should, as we see it nowadays, have been searched at a much earlier date. McClintock sailed in 1857 in the *Fox* of 177 tons, and returned two years later completely successful. He has written the complete story in what is one of the best narratives of any polar expedition. The first year was a failure, the ship having been beset and compelled to drift helplessly for eight months down the middle of Baffin Bay. Next summer McClintock, unmoved by the early setback, succeeded in taking the *Fox* down Prince Regent Inlet to Bellot Strait, where he took up winter quarters at Port Kennedy at the east end of the Strait on September 11. In the spring of 1859 Allen Young, who held the post of Sailing Master, sledged across Peel Sound and completed the examination of the south portion of Prince of Wales Island, and in so doing made it clear that owing to the heavy ice of McClintock Channel it was almost a certainty that that had not been the route taken by the *Erebus* and *Terror*. McClintock himself sledged down the east coast of King William Island and back up the west coast, and found numerous traces of Franklin's men along the route of their last journey. At Victory Point his second in command, Hobson, had by now found the two Franklin expedition records. McClintock completed the circuit of the island, and returned to the *Fox*, having settled both the fate of Franklin and the problem of a Passage. The *Fox* broke out of winter quarters on August 9 and, as soon as the ice permitted, passed into Baffin Bay and reached the English Channel on September 20.

McClintock could now sum up on the possible routes for a Passage, and decide on the merits of the various discoverers. He took the view that Franklin had in 1846 and 1847 discovered the route down Peel Sound and Franklin Strait to Victoria Strait, and that he had therefore been the first to discover a navigable North West Passage.

The further portion of this route along the American Arctic coast was known to Franklin as possible for small boats; he had himself discovered much of it as a young man on his two great expeditions down the Coppermine River in 1821 and down the Mackenzie River in 1826. The credit however of showing that this route was navigable by large ships belonged to Collinson for his eastward voyage in 1852 and return in 1853. McClure must also be given credit for his discovery in 1850 of Prince of Wales Strait and the final link with Parry's discoveries in 1819–20. The Parry-McClure route however was regarded as unsuitable owing to the heavy ice, and the same objection applied to the direct Franklin-Collinson route through Victoria Strait. McClintock held that the best route and perhaps the only one would be a modification of the Franklin-Collinson route east of King William Island.

He puts his own view as follows: "My own preference for the route by the

east side of the island has been formed with a knowledge of Rae's observations on that locality, and of the experience of Collinson to the westward. I am of opinion that the barrier of ice off Bellot Strait, some 3 or 4 miles wide, was the only obstacle to our carrying the 'Fox,' according to my original intention, southward between Boothia and King William's Island towards the Great Fish River, and from thence to a wintering position on Victoria Land. Perhaps some future voyager, profiting by the experience of Franklin, and the observations which my journey round King William's Island has enabled me to make, may succeed in carrying his ship through from sea to sea; at least he will be enabled to direct all his efforts *in the true and only direction*."

McClintock knew without doubt that he could have taken the *Fox* through the inner channels, and in view of what he has said McClintock himself, though he vigorously champions Franklin, must also be given some share of the credit.

Allen Young 1875 *and* 1876

All the waterways were now known, and it only remained to see who would take advantage of McClintock's advice, and be the first to navigate a ship through the Passage.

Allen Young had been with McClintock in the *Fox*, and it was fitting that he should be the first to make the attempt, though not till sixteen years after his return in the *Fox*. Young fitted out the *Pandora*, which he had purchased from the Admiralty. She is described as a despatch gun vessel of 438 tons (Navy register), rigged as a barquentine, fitted with engines of 80 horse-power, and with a complement of thirty-one all told. The intention was to follow the route which McClintock had recommended, and also to undertake further searches for Franklin remains at King William Island. Melville Bay was crossed without hindrance on 16 August 1875, the Cary Islands were visited, and on the 25th the *Pandora* anchored at Beechey Island in Barrow Strait. She then bore across to the south-west, and on August 28 was at Cape Bunny on Limestone Island at the mouth of Peel Sound. Next day she was passing down the sound, but on the 30th was held up by pack-ice about 10 miles north of Cape Bird on the north side of the western entrance to Bellot Strait. In order to see farther ahead than was possible from the mast-head Young landed on the largest of the De la Roquette Islands and from a height of 200 feet could see the entrance of Bellot Strait but with ice tight packed to the shore. Three days were spent waiting for more favourable conditions. The sea was beginning to freeze, and Young considered that it was by now too late in the season to make much further progress. He had therefore to decide whether to winter, with the prospect as far as sledging went of merely repeating McClintock's journeys from the *Fox* and at the same season, or to go home and return next year. He decided on the latter, was back at the mouth of Peel Sound on September 4 and in the English Channel by October 14. Young had come to the conclusion that it would be better for a ship not to go down Peel Sound but to take the route by Prince Regent Inlet to Bellot Strait, wait there for the ice to move northward and westward away from the coast of Boothia, and then when the opportunity came slip through

Bellot Strait and make a dash for Cape Victoria between Boothia and King William Island.

Next year, 1876, Young was ready for a second attempt, but at the last minute the Admiralty asked him to interrupt his plans and take the *Pandora* to the Cary Islands with mail for the *Alert* and *Discovery* which under Nares had entered Smith Sound in August 1875. Young at once accepted, but it proved impossible to combine this commission with his own plans. He failed to contact Nares, and the *Pandora* had to stand by till late in the season. Young was forced therefore to give up any idea of the Passage that year, and on September 7 the *Pandora* was back at Upernavik.

Young made no further attempt, and I have not been able to discover the cause. The Admiralty had apparently relieved him of the cost of the 1876 expedition. Clements Markham, who was his close friend and edited 'The two cruises of the *Pandora*,' gives no hint of what had happened. Young deserved to succeed, he was on the right track, and his voyages were well planned.

Amundsen 1903–06

A generation elapsed, and then the prize which might have been Young's fell to Roald Amundsen. Amundsen, who was twenty-nine at the time, chose as his ship the *Gjöa*, 47 tons with a 13 horse-power motor and a crew of seven all told, of whom one was a magnetic observer and untrained as a seaman. The intention was to combine an attempt on the North West Passage with a full year's magnetic observations in the neighbourhood of the North Magnetic Pole. The *Gjöa* took the traditional route to Lancaster Sound across Melville Bay to the "North Water," and on 15 August 1903 she was at Dalrymple Rock near Cape York, where she took on board a depot of food and oil fuel left on the Rock by Dundee whalers. The *Gjöa* sailed down Peel Sound, passed the west end of Bellot Strait on August 28, and along the east coast of King William Island into Rae Strait. She had thus sailed over the last unsailed portion of the modification of the Franklin-Collinson route recommended by McClintock. The waters lay open and ice-free to the westward, but at this stage the magnetic plans made it necessary to interrupt the voyage. A suitable observatory site was found ashore, and the *Gjöa* was anchored on September 12 in a small harbour on the south side of King William Island. She remained at Gjöa Haven for the two following winters, and was not under way again till 1905, when by rights Amundsen should now have got through to his goal. His luck however for the first time was out, and he was held up by ice not far from the mouth of the Mackenzie River, was forced to winter at King Point, and did not finally reach Bering Strait till August 1906. Amundsen's success was the result of careful planning, of a type which was to be seen again when he achieved his second great success and reached the South Pole. It will have been noticed that he kept his ship at sea much later in the season than Young in the *Pandora*, but no later than McClintock in the *Fox*. His most important decision probably was his choice of a small ship. A larger ship would not only have been too costly, but might also have been in difficulties in the intricate and shallow conditions which prevail over so much of the "inner route." Amundsen's great voyage also showed that a passage in a single summer was a possibility.

Bernier 1908 *and* 1910

By the late nineteenth century much had come to be known about the nature and behaviour of pack-ice. It was not unlikely that the ice was annual in a narrow waterway such as Prince of Wales Strait, forming every autumn and practically disappearing in the following summer. Most of the land-bordered waterways in Arctic Canada south of Lancaster Sound and Barrow Strait behave in this way. The exceptions are the exposed American coast west of Banks Island and such openings as are invaded by heavy ice direct from the Arctic Basin. The most serious invasion of this nature is the ice stream, found by Parry, which presses eastward from the Beaufort Sea between Melville Island and Banks Island and down McClintock Channel to Victoria Strait, where the *Erebus* and *Terror* were caught. The heavy floes there have no unobstructed outlet to the south-east and all reports indicate the difficulties which must occur when a ship is beset between Franklin Strait and Victoria Strait. The same difficulties however need not occur along other parts of this ice stream in places where it is unhindered. Farther to the north-west in Melville Sound conditions might not be so different from those in Smith Sound or in East Greenland where polar floes, just as heavy and possibly even more extensive, are strung out as they drift in summer so that water openings are formed where ships can cut across the ice stream among floes which are dangerous only if tightly packed. It must have been apparent even at the time of Amundsen's voyage that, in spite of Parry's view, the ice in Melville Sound and McClure Strait between Melville Island and Banks Island might be passable to ships and might even be no more difficult to cross than Smith Sound at favourable seasons.

That this was the case was shown by Captain Bernier's voyages on behalf of the Canadian Government to Melville Island between 1906 and 1910. Captain Bernier made his first voyage in 1906, when he took the *Arctic* through Barrow Strait as far as the east point of Melville Island. The *Arctic* was the rechristened *Gauss*, built for a German Antarctic expedition on much the same lines as the *Fram*, 165 feet in length and 37 feet in width and 650 tons gross, 436 tons net. Bernier reached Arctic Point on Melville Island on 29 August 1906, deposited a record, and at once returned eastward to winter at Albert Harbour near Pond Inlet.

Bernier's second voyage and wintering at Melville Island is of much more interest as regards the question of a Passage. On this occasion he took his ship through to Melville Island in the last week of August 1908, and actually sailed her some way into McClure Strait. She then went into winter quarters at Winter Harbour from 28 August 1908 till 12 August 1909.

Bernier's references to McClure Strait during this time are of importance. He sets out at some length the ice conditions as seen daily from his crow's nest at Winter Harbour. On the day of arrival no ice was visible outside the Harbour, and almost daily throughout September Bernier uses the phrase "No ice visible in the strait from crows nest." Occasionally mention is made of "slob," *i.e.* snow afloat and forming into ice, but not as persisting. On September 26 "sheet ice" is recorded with lakes of water visible. This ice also in turn disappeared, and there was "clear water up and down the Strait" on October 1 and 2. The final freeze-up seems to have taken place on

October 15. In the week following presumably heavy polar floes came drifting eastward from the Beaufort Sea, and the strait was apparently completely closed by the first week of November.

The distance which could be seen from the crow's nest was probably not more than 8–10 miles. From Winter Harbour to Banks Island is over 100 miles, and the "strait" of which Bernier writes was only the northern edge of McClure Strait. It is fair however to assume that the almost complete absence of ice day after day throughout September and the first half of October indicates that a much wider space than 8–10 miles was generally ice-free, and that in fact McClure Strait was open and navigable for a period of nearly six weeks. In this connection Lieut. Gurney Cresswell's coloured drawing of McClure Strait made from high up on Banks Island on McClure's expedition is of interest, as it shows open pack-ice with not very large floes, though allowance must also no doubt be made for artistic inaccuracy.

When Bernier first arrived near Winter Harbour on 27 August 1908 he steamed on past Hearne Point, recording no ice along the coast, but signs of pack to the south as shown by a whitish glare in the sky. The *Arctic* passed Cape Providence, and reached a point 20 miles south of Cape Hay, Bernier recording that no ice was visible to the westward, but that heavy Arctic ice was seen to the southward. He adds that he was half-way through McClure Strait, and that, if his instructions had included it, he could have made a North West Passage in the favourable conditions then existing.

Bernier considered Amundsen's route impracticable for merchant ships, and recommended the route by which he had brought the *Arctic* to Winter Harbour, but for the next stage he ignored Prince of Wales Strait and advocated going westward through McClure Strait and down the west coast of Banks Island. Bernier remarks: "Franklin's instructions indicated that the North-west Passage was impossible between Melville island and Banks island, but I am confident, from my own observations, that the conclusion of the Admiralty was erroneous." He was not however the first to take this view. McClintock had already said so when cross-examined by Parry before the Arctic Committee in November 1851.

Bernier made a third voyage in 1910 which again took him, though for a few days only, to Melville Island. On this occasion the *Arctic* was at Winter Harbour from August 31 to September 2. An attempt was apparently made to cross McClure Strait, and the ship went south to Cape Providence, but faced by solid compact ice she turned back at a point where Cape Dundas on Melville Island bore 25 miles north-east. The ice was stated to reach across to Banks Island. From the crow's nest the second officer reported that the ship was 30 miles southward from Cape Providence at noon on September 2, but was later stopped by heavy floes 50–60 feet thick. The ice barrier circled round into Liddon Gulf. Cape Vesey Hamilton on Banks Island was seen quite distinctly. The ship turned back when "We were now 30 miles S.W. of cape Ross, Melville island and had reached the farthest point in this direction of any vessel." On September 4 the *Arctic* again passed Winter Harbour eastward bound, and ultimately wintered at Kikertoo (Arctic Bay) in Admiralty Inlet.

Larsen 1940–42 *and* 1944

Bernier's last attempt was in 1910. The story now moves forward thirty years. Even in Franklin's day the North West Passage had already ceased to be of the same importance as in earlier times. In Elizabethan days it had been sought for a purpose, but by Franklin's time it was known to have no immediate practical value. As in the case of attempts to reach the North Pole it had become an individual and a national ambition. About 1920 however the position changed. The Canadian Arctic had become of interest to the Canadian Government, and the navigability of the channels which separate the Arctic islands became an important question. Vessels were plying all along the American Arctic coast from Bering Strait to the mouth of the Mackenzie and eastwards to Cambridge Bay. It was possible to reach Bellot Strait from Cambridge Bay, and in 1937 the Hudson's Bay Company's ship *Nascopie* on her usual Baffin Bay patrol reached Fort Ross, at the eastern entrance to Bellot Strait, and met the small schooner *Aklavik* which had come from the westward.

Among ships sailing regularly in the waters south of Banks Island and Victoria Island was the *St. Roch*, built and commissioned as a patrol boat for the Royal Canadian Mounted Police in 1928. She is an 80-ton ship, 105 feet in length with 25-foot beam, fitted originally with a 150-horse-power Diesel engine, and since first commissioned under the command of Sergeant, now Sub-Inspector, H. A. Larsen. The *St. Roch* sailed from Vancouver on 21 June 1940 with a crew of seven all told, passed through Bering Strait in the middle of July, and was at Point Barrow on the 22nd. Progress thereafter was slower, and she did not reach the mouth of the Mackenzie till August 17, where she took on board further fuel supplies. On September 8 she was at Cambridge Bay, but it was by then too late in the season to continue the voyage farther eastward, and Sergeant Larsen took his ship back to the west coast of Victoria Island to winter at Walker Bay, where Collinson had wintered in 1851. The voyage began again on 31 July 1941, but first of all a return had to be made on duty to the mouth of the Mackenzie. The *St. Roch* turned eastwards again on August 8, and Cambridge Bay was reached on August 16 and left on the 19th. The waters of Simpson Strait through which the *St. Roch* now worked eastwards are the shallowest and most awkward on the route, but were successfully navigated, and she rounded the south-east point of King William Island and proceeded northwards along the west coast of Boothia. Solid pack-ice however barred the way, the *St. Roch* was edged into Pasley Bay on the west side of Boothia, and after various adventures was forced to winter in this apparently open bay.

She remained at Pasley Bay till 3 August 1942, when she was once more free. It was early in the season, and as she worked north there were troubles with pack-ice, and also for a time with the engine. She was in difficulties again near the Tasmania Islands from August 24 to 26, but Sergeant Larsen was able to reach a high look-out from a hill overlooking Franklin Strait, and as a result took the ship across to Dixon Island off Prince of Wales Island on the 29th. From here the ice conditions improved, and the *St. Roch* was carried through Bellot Strait to the Hudson's Bay Company Post at Fort Ross. The route was then by Prince Regent Inlet to Lancaster Sound. Pond

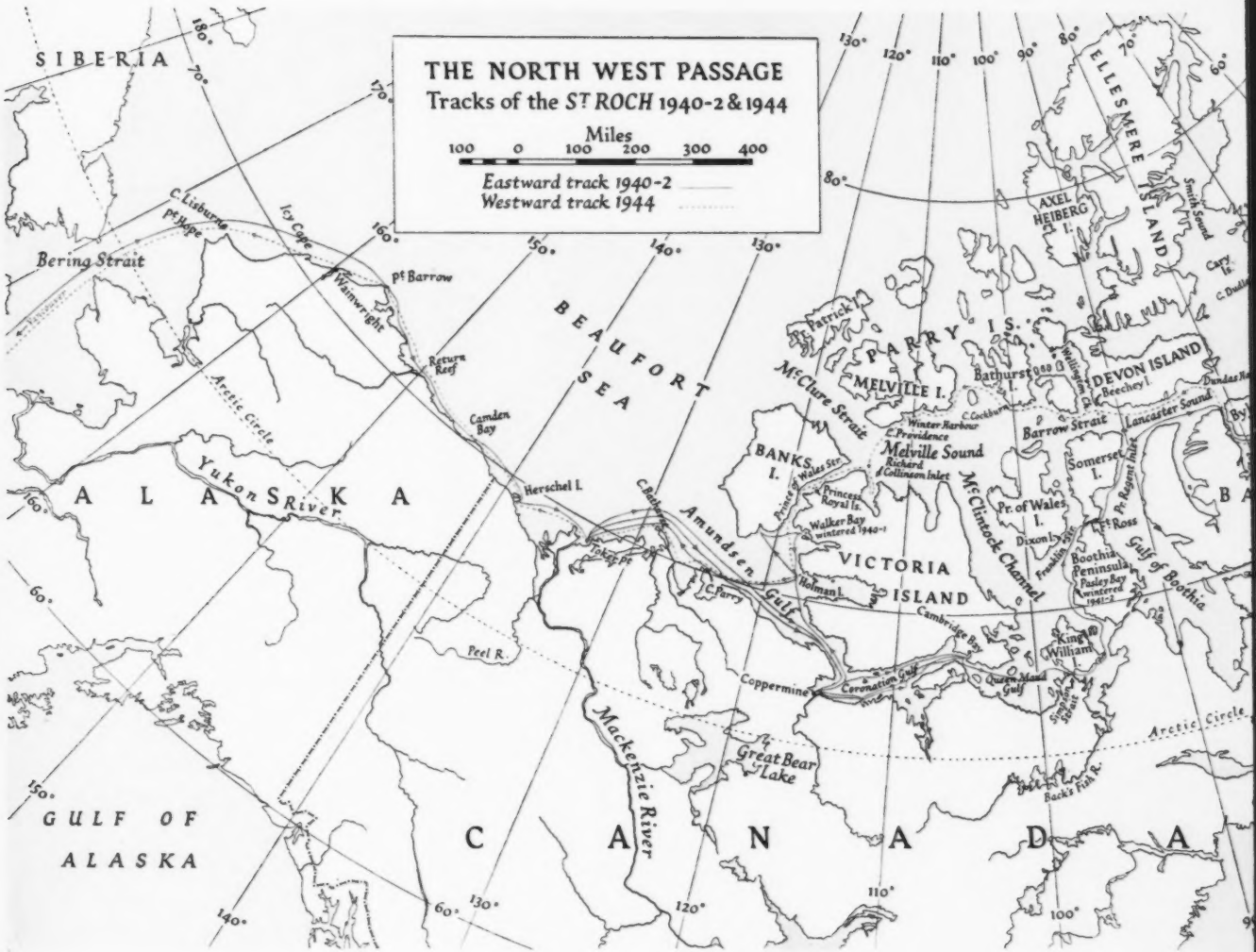
Inlet was reached on September 6; the *St. Roch* left four days later and was at Halifax on 11 October 1942.

Amundsen's route had therefore been repeated, but from west to east, and with a variant through Bellot Strait. In 1940 and in the early part of 1941, the voyage had been more or less routine work on familiar ground, but off Boothia the *St. Roch* was in unfamiliar waters, and Sergeant Larsen, himself a Norwegian, must have worked his ship with skill, and proved a worthy successor to Amundsen.

A still bolder scheme was then put in hand. In 1943 the *St. Roch* had been on patrol in the Hudson Bay area, and in the autumn returned to Halifax. A decision was then made that she should attempt the direct passage by Barrow Strait to Melville Island and across McClure Strait to Banks Island. Larsen, promoted to Staff Sergeant, was again in charge with eight others of a crew and an extra man as far as Pond Inlet. The *St. Roch* sailed from Halifax on 22 July 1944. A new engine, with double the horse-power, had been fitted at Halifax and there were various engine troubles at the start, but these were successfully tackled, and on August 2 she was off Cape Chidley. She proceeded up the west side of Davis Strait, though it was still early for this route, and in spite of persistent fogs reached Pond Inlet on August 12, where she took on board extra equipment and also an Eskimo hunter and his family.

The *St. Roch* was under way again on the 17th, following the usual route westward along the north side of Lancaster Sound and Barrow Strait. Beechey Island was reached late on August 20, and the mouth of Wellington Channel on the 22nd, when, as so often before, it appeared to be clear of ice. There had been various encounters with pack-ice, but there was no serious hindrance till near Cape Cockburn on Bathurst Island, where from 300 feet up on the hills on shore ice could be seen packed to the westward in Melville Sound. The *St. Roch* was held up for some days, but on the 26th the weather was clear with a fresh westerly wind and very little ice was met. Next day there was heavy snow, but it cleared in the afternoon, and a party visited Kellett's cache on Dealy Island, left when the *Resolute* was abandoned in 1854. From there it was a five-hour run on August 28 to Winter Harbour.

Winter Harbour was left two days later. There was a clear run of 30 miles, stopped by heavy ice and thick weather in McClure Strait. Early on the 31st the ship began to work her way south-west from Cape Providence through the heaviest ice met so far. She was held up for over twenty-four hours with very poor visibility, but on September 2 there was a change, the fog lifted, and land loomed ahead. Larsen reckoned that it must be either Peel Point, on Victoria Island, or Russell Point, on Banks Island, the eastern and western headlands of Prince of Wales Strait. Visibility improved on the 3rd, and assuming the landfall to be Russell Point the *St. Roch* worked in east of the landfall. Actually the headland was Peel Point, and the *St. Roch* found herself 15 miles deep into Richard Collinson Inlet, a dead end with every possibility of being hemmed in like McClure's *Investigator* in Mercy Bay. Larsen's luck however was in, and he was able to get his ship back through the ice later in the day and finally into Prince of Wales Strait. Open water was almost certain once inside the Strait, and in the late afternoon of this day of


THE NORTH WEST PASSAGE
Tracks of the ST ROCH 1940-2 & 1944
Miles
100 0 100 200 300 400
Eastward track 1940-2
Westward track 1944
SIBERIA
Bering Strait
C. Lisburne
Pt Hope
Icy Cape
Wainwright
Pt Barrow
Return Reef
Camden Bay
Arctic Circle
Yukon River
A L A S K A
Herschel I.
BEAUFORT SEA
Amundsen Gulf
Tuktoyaktuk
C. Parry
Holman I.
Peel R.
Coppermine
Mackenzie River
Great Bear Lake
GULF OF ALASKA
C A N A D A
Cambridge Bay
Victoria Island
King William I.
Queen Maud Gulf
Simpson Strait
Back's Fish R.
Gulf of Boothia
Boothia Peninsula
Pasley Bay wintered 1941-2
Pr Regent Inlet
Somerset I.
Pr of Wales I.
Dixon Ly
Franklin
Ft Ross
McClintock Channel
Melville Sound
Richard & Collinson Inlet
Princess Royal Is.
Prince of Wales Str.
BANKS I.
Walker Bay wintered 1940-1
Winter Harbour
C. Providence
C. Clothier
McClure Strait
MELVILLE I.
Bathurst I.
PARRY IS.
Patrick I.
Barrow Strait
Lancaster Sound
DEVON ISLAND
Beechey I.
Dundas Harbour
Wellington Chan.
AXEL HEIBERG I.
Smith Sound
ELLESMERE ISLAND
C. Dudley
Arctic Circle

GE
944
00
GREENLAND
ELLESMERE ISLAND
AXEL HEIBERG I.
Smith Sound
Dalrymple Rock
Cape Dudley Digges
C. York
Melville Bay
Upernavik
BAFFIN BAY
PARRY IS.
Patrick
McClure Strait
MELVILLE I.
Bathurst I.
DEVON ISLAND
Beechey I
Dundas Harbour
Lancaster Sound
Bylot I.
Pond Inlet
C. Cockburn
Winter Harbour
C. Providence
Barrow Strait
Melville Sound
Richard & Collinson Inlet
BANKS I.
Prince of Wales Str.
Princess Royal Is.
Walker Bay wintered 1940-1
Somerset I.
Pr. Regent Inlet
Pr. of Wales I.
McClintock Channel
Dixon Ly
Franklin Str.
Ft Ross
Boothia Peninsula
Pasley Bay wintered 1941-2
Gulf of Boothia
BAFFIN ISLAND
VICTORIA ISLAND
Holman I.
Gulf
Cambridge Bay
King William I.
Foxe Basin
Coronation Gulf
Queen Maud Gulf
Simpson Strait
Arctic Circle
Foxe Channel
Back's Fish R.
Southampton I.
HUDSON BAY
110°
100°
90°
80°
70°
60°
50°
40°
130°
120°

changing fortune and final success the *St. Roch* was steaming at 7 knots past the Princess Royal Islands. The critical crossing from Melville Island to Banks Island took five days.

Walker Bay was passed on September 4, and contact made the same day with the Hudson's Bay Company Post on Holman Island, where the *Fort Ross* had arrived the day before from the west, having reached this point from Halifax via the Panama Canal. Cape Parry and Cape Bathurst on the Canadian mainland were passed on September 6. Two days later the *St. Roch* was anchored off the Hudson's Bay Company Post at Tuktoyaktuk (or Tuk Tuk), but on the morning following a hurricane got up, and she was held prisoner for six days. At one time it seemed likely that a wintering would be necessary, but on the 17th she managed to get away to Herschel Harbour, where the Pond Inlet Eskimo was put ashore before leaving Canadian territory.

Port Barrow was rounded in thick fog on the 24th, and from there on there was no more ice. Cape Lisburne was passed on September 25, and Point Hope on the 26th; and four days later the *St. Roch* was at the U.S. Naval Base at Akutan. On October 4 Larsen took his ship through the Unimak Pass, and his log records "Entering the Pacific at 18.35." Vancouver was reached twelve days later, and the long voyage was at an end—7295 miles from Halifax in 1031½ steaming hours, and a total time at sea from Halifax to Vancouver of eighty-six days.

Larsen fully deserved his success. The passage across McClure Strait was not an easy one, and could only have been made by an ice pilot of competence and determination. I have mentioned some remarkable voyages in the days of the Franklin search, particularly McClure's up the west coast of Banks Island and Collinson's to Cambridge Bay, and Larsen's voyage in 1944 can be placed alongside them.

It may also serve as an illustration of the particular qualities which make for success in polar exploration, and in this connection I should like to quote from a letter written by General Wolfe in 1757:

> "Experience shows me that . . . pushing on smartly is the road to success; that nothing is to be reckoned an obstacle to your undertaking which is not found really so upon trial; *that in war something must be allowed to chance and fortune, seeing it is in its nature hazardous and an option of difficulties;* that the greatness of an object should come under consideration as opposed to the impediments that lie in the way; that the honour of one's country is to have some weight; and that in particular circumstances and times the loss of a thousand men is rather an advantage to a nation than otherwise, seeing that gallant attempts raise its reputation and make it respected."

Exploration has much in it that calls for the same qualities and attributes as war, and many will I feel sure find Wolfe's remarks just as fitting to most of the voyages which I have tried to describe.

DISCUSSION

Before the paper the PRESIDENT (The Rt. Hon. Sir GEORGE CLERK) said: On 18 May 1845, Sir John Franklin sailed from Greenhithe with the *Erebus* and *Terror* with the hope of finally achieving the North West Passage. Though destined to a disastrous end, this expedition is an outstanding event in the history of Arctic exploration. The desire to ascertain its fate was for long an impetus to further exploration, which resulted in the charting of the Canadian Arctic.

Perhaps I might mention here a fact which added to that desire. Not only was Franklin a hero, not only was the North West Passage the dream of navigators for centuries, not only was the loss of these two ships and the gallant and picked men who were their officers and crews felt throughout the country, but departmental considerations also came into it. Until the facts regarding the definite end of the *Erebus* and *Terror* were ascertained the Admiralty were faced with financial questions of payments to dependents. I do not know if there are any high-ranking members of the Civil Service present to-night, but I am convinced that the Treasury then, as now, felt they must know where they stood, because they could not go on paying these amounts, perhaps overdue. It is, of course, most difficult to reconstruct the atmosphere of the time, but one hundred years ago and during the years that followed, the fate of Franklin and his companions was felt throughout the length and breadth of this country.

It is fitting therefore that this Society should commemorate the centenary of the event, and honour one of the great figures among British explorers. This centenary falls also at an appropriate time, for only three years ago the first voyage through the North West Passage from west to east was completed by the Royal Canadian Mounted Police patrol vessel *St. Roch*, under the command of Sergeant Henry A. Larsen, and last year Sergeant Larsen made the return voyage from Halifax to Vancouver in one summer.

To-night we are to hear two authorities on varied aspects of the Franklin expedition. Dr. Richard Cyriax has a profound knowledge of the history of the expedition, and will deal particularly with the orders given to Franklin in the light of contemporary geographical knowledge. Our Honorary Secretary and Gold Medallist, Mr. J. M. Wordie, has had much experience both in the Arctic and Antarctic, and has made the history and technique of Polar exploration his special study. He will deal with the course of the various relief expeditions and the successful navigation of the North West Passage by Amundsen and Sergeant Larsen.

Dr. Richard Cyriax and Mr. J. M. Wordie then read the papers printed above.

The PRESIDENT: We have with us to-night a very distinguished sailor who has held for thirteen years that great office of Hydrographer to the Navy and who knows the subject to which we have been listening better than almost anybody. Perhaps Admiral Sir John Edgell will add a word.

Vice-Admiral Sir JOHN EDGELL: My first reaction to the interesting lectures to which we have listened was a recollection of a sentence in the Old Testament that "there were giants in those days." When you come to think of the amount of exertion which was necessary to go 2 or 3 miles with the heavy sledges, the poor equipment, the not particularly adequate victuals, and the obstacles which had to be overcome, due mainly to the almost entire lack of knowledge of what lay round the corner, it is astonishing that so much progress was made and that information was gathered which became of such importance to those who followed after.

Talking of those who followed after, you heard how Sir Edward Parry was largely responsible for the inauguration of the first expedition under Franklin. Names in the Navy follow down through the centuries. There was an Edward Parry in those days; in the last war there was a John Franklin Parry, one of my predecessors as Hydrographer of the Navy. At the Battle of Coronel there was a Philip Franklin, Captain of the *Good Hope*. So with other names, McClure, Collinson, McClintock, Kellett, FitzRoy, they still carry on the old work which was done in the days of Franklin and McClure. To-day the difficulties may not be as great; and that is an interesting point because among the many duties of the Hydrographer is that of advising the Board of Admiralty on all matters connected with exploratory work. In the course of my time at the Admiralty I have had to advise the Board on the question of the award of the Polar Medal, which is something we are very jealous of. It is not lightly awarded, and one of the particular reasons why the Medal was given in days gone by was on account of the degree of hardship endured by those taking part in the expeditions. I felt it necessary rather to rule that out because in these days, with modern inventions and the help which explorers get from them, the hardships are not the same as they were in the past. They cannot be. The whole principle is the spirit of adventure; and the desire to obtain knowledge is the same now as it was in days gone by. I am only too thankful that that is so.

The PRESIDENT: We have heard what I venture to call a remarkable duet, a story concisely and brilliantly told of the efforts of generations, finally crowned not with spectacular but with really practical success. I am sure you agree with me that to listen to the two papers has been an education in what was done two generations ago.

DIFFERENT TYPES OF ISLAND-ARCS IN THE PACIFIC

J. H. F. UMBGROVE

FOURTEEN YEARS ago a simple interpretation of the form of island-arcs was put forward by Lake in the *Geographical Journal*.[1] From a morphological analysis of the island-arcs bordering the Pacific side of the Asiatic continent he suggested that the presence of a deep-reaching thrust plane at the base, dipping continent-ward from the Pacific, would account for the shape of the arc. The trace of any large thrust plane cutting the earth's surface is necessarily arc-shaped on the sphere, and the degree of curvature of the arc depends on the angle which the thrust plane makes with the earth's surface.

At the time the theory was announced no geologist would have had the audacity to maintain one of its fundamental consequences, namely large thrust planes along the island-arcs of the Pacific reaching down to a depth of several hundred miles. A few years later however deep-focus earthquakes were recognized in the same areas and their actual distribution induced Wadati to postulate a large shear-plane dipping continent-wards from the marginal deep off Japan and reaching a depth of nearly 700 kilometres. For the moment the existence of deep-reaching shear-planes connected with the island-arcs of the Pacific seems hardly open to doubt. And we have to examine whether other features can be reconciled with them into a synthesis that includes the morphological, geological, and geophysical aspects of the regions under consideration.

Island-arcs are associated with several other remarkable features. Deep-sea furrows are situated along their outer or convex sides; deep basins appear on their inner or concave sides. Belts of large disturbances of isostatic equilibrium accompany them. And probably terrestrial magnetism shows noticeable deviations from its normal values in these arcuate island-zones. A further question which deserves special attention is whether island-arcs differing in physiographic aspect represent at the same time different evolutionary stages in the history of a tectonic belt, or not.

The following pages contain a short synopsis of the most remarkable features and problems concerning the origin and structural history of the island-arcs. A more exhaustive and amply illustrated discussion of the subject will be published elsewhere.[2]

Phenomena that are in favour of Lake's theory will be considered first.

[1] P. Lake, "Island arcs and mountain building" (*Geogr. J.* 78 (1931) 149–160). See also W. J. Sollas, "The figure of the Earth" (*Quart. J. Geol. Soc. Lond.* 59 (1903) 180–188), and A. C. Lawson, "Insular arcs, foredeeps and geosynclinal seas of the Asiatic Coast" (*Bull. Geol. Soc. Amer.* 43 (1932)).

[2] J. H. F. Umbgrove, 'The pulse of the Earth' (Nijhoff, The Hague). Second Edition in preparation. The subject will appear as a separate chapter under the title "Island-arcs" and will include an extensive bibliography.

Then a classification into three types of island-arcs will be given, and these types will be discussed. Finally some remarks will be devoted to the possible genetic relations of island-arcs and other arcuate structures on the continents.

General aspects.—Deep-focus earthquakes occur beneath extensive belts along the western border of the Pacific Basin proper and beneath a smaller area in South America.[1] The character of the seismic disturbances clearly demonstrates that, like normal tectonic earthquakes, deep-focus shocks originate by a mechanism involving shearing and faulting.

The zone of deep foci occurs on the continental side of a zone of intermediate focal depth and this in turn is succeeded by a zone of normal foci near the Pacific border, terminating in a deep-sea trough of the type called a marginal deep. Probably all three classes are situated in successive order along a surface—or a zone of shearing planes—which from a marginal deep-sea trough gradually slopes downward under the continent, where it reaches a depth of approximately 700 kilometres. The gradient of the "seismic surface" is generally 30–40 degrees, but reaches 55 degrees in the Moluccas.

Hence Lake's theoretical deduction based on physiographic evidence receives strong support from seismic data. Deep-reaching shear-planes seem to be associated with the island-arcs of the western Pacific. From the various maps it appears that for the most part the zone of normal shocks "crops out" on the sea-floor within the marginal deep-sea troughs. Certainly this seems to be the case in the Japanese and South American districts, and probably it holds good for such regions as the western and south-western border of the Pacific Basin.

The theory of convection currents in the earth, as defined by A. Holmes and elaborated by Vening Meinesz,[2] assumes opposing currents along the boundary between continents and the oceanic area of the Pacific Basin. Possibly effects of shearing and fracture might be induced where a current of one system turns downwards as it approaches the opposing current of another system. For it appears from modern experiments by Bridgman, Griggs, and Haskell that no discrepancy arises from the notion of deep-reaching shear-planes and the theory of thermal convection currents in the earth. The western boundary of the field of positive anomalies of gravity in the Pacific was found to coincide with the boundary of the island-arcs. It is at the same time a petrographic boundary: the "andesite-line." Probably a thin sial-layer covers the ocean bottom between the Philippine archipelago and the single arc of the Marianas islands.

According to Visser[3] convection-currents transporting material with special magnetic properties towards more peripheral parts of the earth's interior from deeper realms, would cause positive anomalies of terrestrial

[1] *Cf.* B. Gutenberg and C. F. Richter, "Depth and geographical distribution of deep-focus earthquakes" (*Bull. Geol. Soc. Amer.* 49 (1938)); "Seismicity of the Earth" (*Geol. Soc. Amer., Special paper* No. 34, 1941; and *Bulletin* 56 (1945)).

[2] *Cf.* A. Holmes, "The thermal history of the Earth" (*J. Wash. Acad. Sci.* 23 (1933)) and A. Vening Meinesz, "Gravity and the hypothesis of convection-currents in the Earth" (*Proc. Kon. Nederl. Akad. Wet.* 37 (1934) 37–45).

[3] S. W. Visser, "A connection between deep-focus earthquakes and anomalies of terrestrial magnetism and gravity" (*Terr. Magn. Atmos. Elect.* 42 (1937) 361–2).

magnetism. However, conclusions regarding a relationship between deep-focus districts and anomalies of the vertical component of terrestrial magnetism stand in obvious need of confirmation by more detailed investigations.

During epochs of increasing compression the earth's crust reacted by the development of large waves of 200–400 kilometres in length. According to the theoretical deduction of Vening Meinesz [1] the amplitude of the crustal waves increased until in one of them the strength of the crust was surpassed. The crust then broke at the weakest place of a downward wave and buckled inwards so as to form a sialic root penetrating the simatic substratum. Obviously the outcrop of a deep-reaching seismic shear-plane, or zone of shear-planes, was such a weak place *par excellence*. So the crustal buckle was predestined to originate in a downward wave of the earth's crust that was weakened by a deep-reaching shear-plane. The downward buckle of the sialic crust is revealed by a zone of strong negative isostatic anomalies of gravity. The different geological and volcanological phenomena dependent on the formation of the zone of buckling and the accompanying upward and downward crust-waves will be considered presently. In order to simplify discussion only two crustal layers have been drawn in Figs. 1, 3, and 4. The upper layer—indicated as "sial"—includes the "intermediate layer" which however will not be considered in the present article.

Classification.—Island-arcs may be classified into three different types, namely double arcs, pseudo-single arcs, and single arcs. The Ryukyu Islands and the East Indies are good examples of a double festoon. The Kuriles and Aleutians are double over a short distance, but single over the greater part of their extent. In origin they are closely allied to the double arcs. True single arcs, like the Bonin and Marianas arcs, had a very different structural history.

It will be shown that the development of a single or double arc depends on the thickness of the sialic part of the crust and the quantity of sediment on the sea-floor above the crustal buckle. We may now proceed to discuss the three types of arcs beginning with the double arc of the East Indies.

Double island-arcs.—In the region of the East Indies the sialic crust is of continental thickness. Large areas protruded above sea-level for some time before the formation of the crustal down-buckle. Accordingly large quantities of waste products from the land accumulated in the downward-moving crustal wave. When the latter was down-buckled its contents became crumpled and squeezed out so as to form a ridge-shaped elevation above the zone of buckling. Hence the belt of negative anomalies is found to occur over the ridge. Whether the ridge appears as a submarine feature or as an island-arc depends on the quantity of strata that was squeezed out and then upraised during the ensuing period of decreasing compression. The Ryukyu and the

[1] F. A. Vening Meinesz, J. H. F. Umbgrove, and P. H. Kuenen, 'Gravity expeditions at sea 1923–1932,' vol. 2 (Netherlands Geodetic Commission, Delft, 1934); and F. A. Vening Meinesz, "The earth's crust deformations in the East Indies" (*Proc. Kon. Nederl. Akad. Wet.* 43 (1940) 278–93). The phenomenon of buckling and wave-formation was elucidated experimentally by P. H. Kuenen, "The negative isostatic anomalies in the East Indies, with experiments" (*Leid. Geol. Meded.* 8 (1936) 169–215).

East Indian festoons are types of arcs that formed in this way. But only in the case of the East Indies are paleogeographic data available to substantiate the theory.[1] The region of the archipelago was probably an extensive land area at the end of the Mesozoic and the beginning of the Eocene. During the ensuing Eocene and later transgressions a western area still remained above sea-level, including large parts of Borneo, Malaya, the present Java Sea, South China Sea, and Sumatra. A second large land-area existed in the south-east including northern Australia and the present Arafura Sea. It is along these areas that the zone of buckling appears as an island-festoon, whereas the intervening strip developed only as a submarine ridge.

The time of origin of the crustal buckle, hence also of the deep-reaching shear zone, may lie in a very remote past. However the features were rejuvenated time and again, during ensuing epochs of compression. In the East Indies the first crustal down-buckling in the present zone of strongly negative anomalies of gravity occurred during the early Triassic at least—if not in more remote times. The most recent epoch of strong compression in the same belt dates from the Upper Miocene. Restoration of isostatic equilibrium is rather a slow process. For even if the root disappears by melting and spreading, the sialic bulge in the crust still remains to give rise to a negative anomaly many tens of million years afterwards.

In the schematic diagram, Fig. 1, A shows the crustal buckle. The figures I–III correspond with those on the folding-map (following p. 248). To the left two parallel waves are drawn, one upward and one downward. They respectively represent zones II and III of the sketch-map. It may be assumed that profile A represents a Tertiary epoch of compression and rejuvenation of the root in zone I.

Sedimentation starts in the downward moving troughs III. Plutonic and volcanic activity begins in the upward-moving geanticlinal belt II, in a way to be considered later in some detail.

As soon as the compression in the crust decreases the process of restoration of isostatic equilibrium begins, and thus the sialic root must have a strong tendency to rise. Consequently simatic material will flow towards the buckled belt and, as a further consequence, a furrow will form on either side of the folded zone.[2] This stage is represented by Fig. 1, B.

One of these furrows will come into being between the volcanic belt and the root, Ia, the other at its convex front, Ib. The first corresponds with the deep-sea basins between Sumatra and the row of islands to the west of it. The second corresponds with the series of marginal deep-sea troughs running along their oceanic side.

[1] *Cf.* J. H. F. Umbgrove, "Geological history of the East Indies" (*Bull. Amer. Ass. Petrol. Geol.*, 22 (1938), Figs. 6, 8, 9, and 10).

[2] These furrows were attributed by Vening Meinesz (*op. cit.* 1940, p. 290) to a wave formation of the crust due to increasing compression. The vertical movements in the Pleistocene and the belts of positive and negative anomalies were interpreted by him in the same way. The site of the island of Sumba as well as the submarine topography in its vicinity turns out to be intimately related to the interruption of the belt of negative anomalies in that area. Sumba stands as the exceptional evidence of a sort of terrain that elsewhere subsided so as to form the bottom of a deep-sea furrow between the outer and inner arcs.

So, whether the intervening belt of folded strata (zone I) appears as a submarine ridge, or as an island festoon, depends on the quantity of strata that was squeezed out. The second possibility is represented by Fig. 1, B. In this case a double island festoon has come into being, an inner volcanic arc and, parallel to it, an outer arc which at this stage is non-volcanic (Fig. 3).

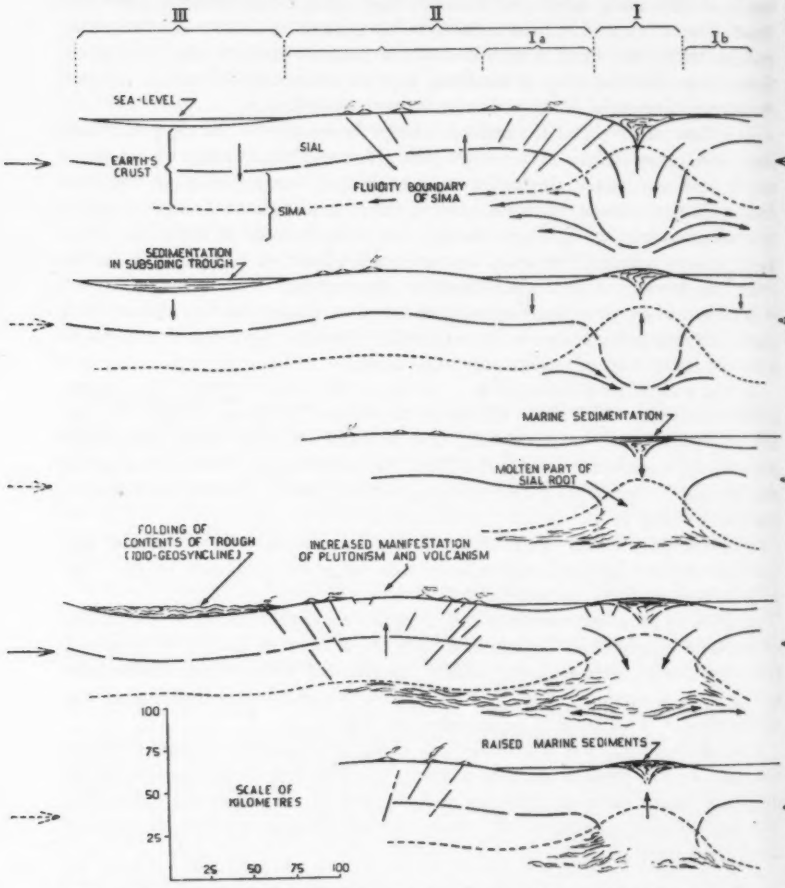


Fig. 1. Schematic sections showing the development of a double island festoon and accompanying features. The figures I–III correspond to those on the folding-map

In all probability the downward folded root would not remain intact. It is reasonable to assume that the sialic matter of the root began to melt and spread. As a result the central part of zone I began to subside, forming a shallow depression (Fig. 1, C). An actual depression of this kind is known as the central "graben" or "geosyncline" on Timor, containing a sequence of a

few hundred metres of Pliocene sediments. Similar features are known from the Kei islands, Tanimbar islands, and Ceram.

The subcrustal migration of sialic material on either side of the root ought to cause a rising movement of the bottom of both the troughs Ia and Ib. The depth of the fluidity boundary of the sima (the so-called Mohorovičić discontinuity) increases towards regions of Ib, due to the thinning out of the sialic crust layer towards the Indian Ocean. This situation causes the asymmetric spreading of subcrustal sial as shown by the sections C, D, and E. Therefore the rising movement of the bottom of trough Ia ought to surpass that of Ib. Now a glance at the bathymetric map shows the Ia trough between Sumatra and the Mentawai islands to be much shallower than the marginal deep off the Mentawai islands; the same holds good for the Ia and Ib troughs south of Java. At first sight these data seem in remarkable agreement with the theoretical deductions. However, between Sumba and New Guinea the bathymetric map shows exactly the reverse, the marginal deeps being shallower than the Ia troughs. In this part of the East Indies the marginal deeps are bounded by the shelf area of Australia and New Guinea, which was an extensive area of denudation during most of Tertiary and Pleistocene times. In the western part of the East Indies an extensive area of denudation existed along the opposite side of the arc, bordering the Ia troughs.

Hence it appears that the bathymetric effect due to the spreading of sialic material below the crust, is a factor of minor importance if compared with the effect due to sedimentation. The same conclusion follows from a comparison of the depth of the Weber deep and the gravimetric map, to which reference will be made below. Indeed, if the spreading of the sialic material of the root takes place in the form of thin films and filaments, as suggested by section C, the phenomenon would be of much less importance than the opposite, *i.e.* upward movement of zone I.

The ensuing epoch of compression at the end of the Pliocene, represented by Fig. 1, D, caused a moderate folding of the contents of zone III. The shallow depression of zone I was only slightly influenced at this stage, certain tectonic features at the margin of the shallow "geosyncline" being the only phenomena that have been noticed. The plutonic and volcanic processes of zone II became more active.

The last stage, represented by Fig. 1, E, shows the most recent period of decreasing compression. Again zone I rises isostatically. The contents of the central depression are now raised above sea-level, in places several hundred metres, and locally even more than a thousand.[1] Zone III also rises isostatically but to a slighter degree, and the plutonism and volcanism of the geanticlinal belt II decreases to its present though still active phase. Again the root melts and spreads laterally in the substratum. A comparison of the gravimetric and bathymetric maps shows for example that the sialic root has spread beneath the site of the Weber deep in the vicinity of the Kei islands.

According to the considerations just mentioned the topographic and bathymetric features of the East Indies should be of comparatively recent origin.

[1] Upper Tertiary sediments of the Masi-Bobot graben of Ceram are now at least 3000 metres above sea-level, and Pleistocene sediments of central Timor as much as 1280 metres above sea-level.

They should all have come into being since at least the last epoch of strong compression in the Miocene. And this is what has been concluded from geological and morphological data.[1] It would appear, moreover, that the deep-sea furrows Ia and Ib are of still more recent origin than the depressions of zone III. In the same way the most recent elevation of zone I began later than the last rising movement of zone II.

The upward wave accompanying the zone of buckling on its continental side (zone II, Fig. 1) is more strongly developed than the wave on its convex side. It is moreover always a volcanic arc. These striking features may probably be explained in the following way. Subcrustal sima was pushed aside by the downward-penetrating root. The curved shape of the arc involved centripetal crowding of the sima at the concave side of the arc, whereas on the convex side it could expand more freely. This caused the arching of the geanticlinal belt to be sustained by the accumulating sima and hence to become a belt of active plutonism and volcanism. Emanations from the substratum ascended in these parts and by a process of migmatization of pre-existing crustal rocks formed granitic batholiths. Thus, in a double festoon, the inner arc will always be a volcanic arc.

Plutonism and volcanism were rejuvenated during ensuing epochs of increasing crustal compression. During the same epochs longitudinal faults and rift valleys developed in the crest of the geanticline (Fig. 1, D, II). These are the loci of strong tectonic earthquakes of the normal class. The acid and volatile-rich character of the ascending migmatite front gave rise to strongly explosive volcanism which resulted in the formation of volcano-tectonic depressions.

Obviously the process responsible for the upward movement of the inner arc differs fundamentally from that which caused the rising of the outer arc. For the outer arc rises on account of the large sialic root, which tends to regain a state of isostatic equilibrium during a period of decreasing compression of the earth's crust. On the other hand, the inner arc rises as an upward wave of the crust during an epoch of increasing compression. In the outer arc, the downward penetrating root of sial prevented the development of plutonic and volcanic manifestations, such as those which characterize the inner arc during an epoch of increasing compression. During a period of decreasing compression granitic batholiths growing upwards from the root seldom penetrate to a sufficiently high level to be revealed at the surface now exposed by the erosion of the outer arc.

The double row of volcanoes of north Celebes and Halmahera (see folding-map) seems to be related to the double-concave development of the zone of buckling, which can be inferred from the contours on the map of isostatic anomalies. In accordance, a deep-sea furrow exists along each side of the root (Fig. 2), and here the extraordinary high values of the negative anomalies as well as the broadness of the negative belt may well be due to two sets of deep-reaching shear-planes, one dipping westward, the other eastward.

The absence of active volcanism from the inner arc to the north of Timor is probably controlled by the exceptionally strong compression to which the crust is subjected in that arc, due to the formation of the marginal Timor

[1] See Umbgrove, *op. cit.* 1938, pp. 55–58.

deep, and more especially to that of the subsiding Savu trough (*cf.* Fig. 2 and map). For in this area the subsiding troughs on each side of the zone of buckling had to become adapted to the limited space between the inner arc and the Australian continent.

As mentioned above, a downward crustal wave formed along the continental side of the inner arc during an epoch of increasing compression (zone

Fig. 2. Deep-sea basins and troughs in the Moluccas (after P. H. Kuenen). A. Sulu basin; B. Celebes basin; C and D. Banda Sea basins; a. Makassar basin; b. Boni basin; c. Tomini basin; I. Java trough; II–VII. Timor–Ceram and Molucca troughs; VIII. Mindanao trough; IX. Flores trough; 1. Weber deep; 2. Savu trough; 3. Java–Mentawai trough.

III, Fig. 1). If the quantity of available waste-products from the surrounding land-areas equals or surpasses the rate of subsidence of the bottom the furrow will gradually become filled up, to appear as a geosynclinal trough (idio-geosyncline). However if the rate of subsidence surpasses the supply of sediments, a deep-sea basin will originate. The Flores-deep may probably be cited as an example.

The peculiar shapes of the Banda Sea basins are due to a process of inter-

ference between neighbouring downward crustal waves, resulting from the vortex-shaped pattern of buckled zones.

Fields of strong positive anomalies of gravity show a clear parallelism and relationship to the belt of strongly negative anomalies (see folding-map). They partly coincide with ridge-shaped elevations of the crust, partly with deep depressions. Therefore the cause of the anomalies has to be sought not in crustal but in sub-crustal phenomena. When the sial-root penetrated downward the heavier masses of the substratum were pushed aside. Probably a deep-seated layer of heavy material, such as dunite, was influenced in much the same way as the sub-crustal basalt-layer.[1] Such displacements would be revealed as belts of positive anomalies on either side of the negative belt and at a comparatively short distance from it (Fig. 3). The more complicated pattern of negative zones in the Moluccas suggest phenomena of

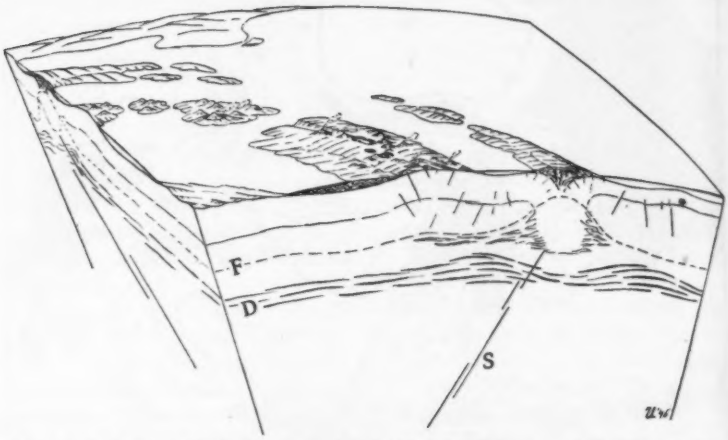


Fig. 3. Schematic block diagram of a double island festoon of the East Indian type. F. fluidity-boundary of sima; D. dunite layer; S. zone of shear-planes. (For an explanation of sub-crustal and crustal layers see Fig. 1)

interference, but the situation of the positive fields may be explained according to the same causative principle.

The four-armed morphology of Celebes is an expression of a double arc, which—unlike the other arcs along the border of Asia—has its convex side turned towards the Asiatic continent. The inverted position of the Celebes

[1] A periodite-layer is probably present in the substratum below a layer having the composition of olivine-basalt. This explains why periodite intrudes a mountain-root only during its first far-reaching down-buckling, whereas later epochs of compression, implying a rejuvenated down-buckling of the sial-root, fail to be accompanied by another series of periodite intrusions.

The continents are rejuvenated periodically by receiving a supply of sialic melts derived from the spreading, migration, and subsequent ascent of sialic melts from the molten part of mountain-roots and from subsided parts of the crust such as basins and submerged borderlands.

arc is caused by the sum of forces interacting in the region between Asia and Australia. It forms part of the whirl-shaped pattern of the Moluccas, which is due to the presence of the continental block of Australia, including the Arafura Sea and New Guinea. The continental sial-mass being much thicker and penetrating deeper than the comparatively thin sial-cover of the floor of the Indian Ocean and the sial-free bottom of the Pacific, must have considerably hampered the free development of sub-crustal processes towards the south-east and east. However a mechanical interpretation of the puzzling island-arcs of the Moluccas, including Celebes, is not yet possible, as our geological and geophysical knowledge of the adjacent regions is too scanty. Data are especially lacking from New Guinea and Halmahera on one side, and from Borneo on the other side.

Among the exceptional features related to the inverted position of the zone of buckling in East Celebes are the absence of a volcanic "inner" arc along its concave side and the numerous manifestations of upper Tertiary to Recent volcanism and plutonism on its convex side. As a tentative explanation it is suggested that two cooperating factors suppressed the formation of an "inner" arc. One of these was the interaction of crustal processes that caused the floor of the Banda Sea to subside deeply in the shape of a wide basin. The other was the accumulation of dunite masses that were laterally displaced from the zones of downward-buckling. Both factors worked in opposition to the formation of an "inner" arc. Hence, in this exceptional case, the basaltic material of the substratum that was pushed aside by the root under the eastern part of Celebes had to flow towards the convex side of the zone of buckling, where it set going the genetic processes responsible for the numerous granodioritic intrusions and manifestations of upper Neogene volcanism in the western division of the island.

Pseudo-single arcs.—A shallow sea covers the area behind the Kurile and Aleutian arcs, apart from a deep basin that came into existence immediately behind the arc. These arcs both continue into continental areas: the Kurile arc into Kamchatka, the Aleutian arc into Alaska. In all probability the sial-crust behind the arc is of continental thickness. And we must ascribe it to paleogeographic conditions that over its greatest extent the Kurile arc developed as a single arc instead of a double festoon. The arc is double only in the vicinity of the north island of Japan. The Aleutian arc is double only along a section of its eastern part.

Single arcs.—The situation of the Marianas and Bonin arcs is fundamentally different. The sea-floor behind the arcs is some 2000–2500 fathoms deep or more. This means that the sialic part of the crust is comparatively thin over an area extending for more than 1500 miles westward as far as the Ryukyu and Philippine islands. Accordingly sedimentation in this area is free from waste products from the land. Hence a double island festoon of the Ryukyu or East Indian type could not possibly come into being in the area of the Marianas nor will it ever be able to develop in the future. For if the zone of buckling be far from continental land, a deep-sea furrow will come into being above the sialic root, and negative anomalies will be found above the deep (Fig. 4). On the continent-ward side the deep-sea furrow will be accompanied

by a single volcanic island arc. Examples are Guam with the Nero deep and Yap with the Yap deep. The anomaly curve across Guam and the Nero deep is asymmetrical. This seems best explained by assuming that the eastern sector has been thrust under the western part. On the other hand the gravimetric profile across Yap and the Yap deep is more symmetrical. Accordingly the existence of a symmetrical sial root is more probable. It follows from the above considerations that the marginal deep of a double arc is genetically different from the marginal deep of a single arc.

Possibly the loci of shear-planes and accordingly the sites of the arcs correspond with the boundaries of sial layers of different thickness. So the

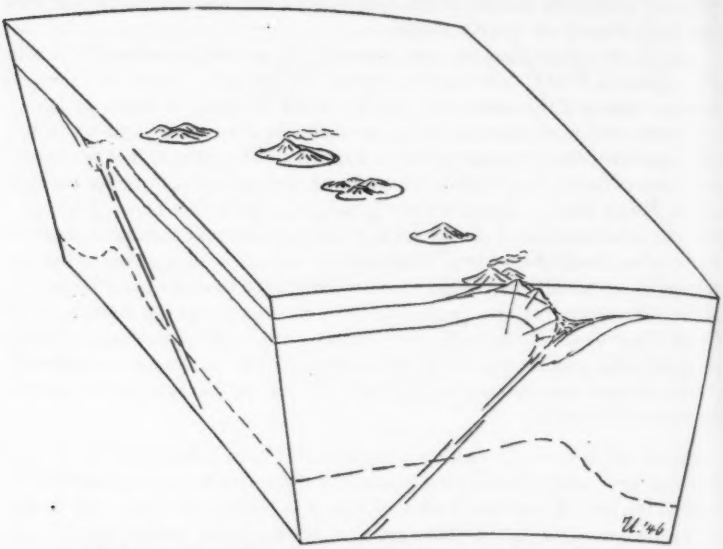


Fig. 4. Schematic section through Guam and the Nero deep

Marianas and Bonin arcs developed near the boundary between the sial-free Pacific Basin proper and the thin sial layer extending from the Marianas to the Philippines and the Ryukyu islands. The latter developed where the thin sial layer passes into one of continental thickness, whereas the Kurile and Aleutian arcs came into being on the boundary between a crust of continental type and the basaltic floor of the Pacific. Given stable conditions of crustal thickness and such waste-products as are available, the Marianas arc might appear and vanish periodically, according to the alternating rhythm of epochs of increasing crustal compression (accompanied by arc-formation) and decreasing compression (accompanied by decreasing volcanic activity and denudation of the island-festoon).

It follows from our considerations that the different physiographic aspects presented by such mountain-belts as the Alps, the Himalaya, the structural

belts of Burma, and the island-festoon of the East Indies do not represent different evolutionary stages in a continuous process of mountain-making. The differences are mainly controlled by the thickness of the crust, the available quantity of waste-products from the land, and the paleogeographic conditions that prevailed during the structural history of each region, more especially during the latest epoch of increasing crustal compression.

The position of two regions along the eastern border of Asia, namely Japan and the Philippines, is exceptional in so far as several arcs meet in these areas and form an intricate pattern. A detailed study of all the available data on the stratigraphy, paleogeography, structural history, and geophysics of the regions would be needed in order to elucidate their remarkable features. As regards the Philippine archipelago the report by B. Willis [1] unmistakably testifies to our still too scanty knowledge on the geography, geology, and geophysics of that island-group. For lack of sufficient data, the entire region extending from New Guinea to Samoa has also to be left out of consideration. Other unsolved problems are offered by the eastern margin of Melanesia and the Pacific coast of America. For Melanesia is bordered by the Kermadec and Tonga deeps and a volcanic line runs from New Zealand to the Samoa islands. The problem here is that the trends are not arc-shaped but rectilinear. One might assume the existence of a shearing plane that dissects the crust almost perpendicularly. But deep-focus earthquakes are known in the region west of the Tonga deep as far as the Fiji islands and their distribution is not in accordance with the suggestion of an almost perpendicular shearing plane. As to South America it should be noted that it is a region of considerable plutonism and volcanism. Along the coast there is an interrupted series of deep-sea furrows. Numerous deep-focus earthquakes which have their epicentres east of the Andes have been recorded from four areas. But remarkably enough no island-festoons were developed. On the other hand no deep-focus earthquakes and no deep-sea furrow is known from the Pacific coast region of North America, though an island-arc, partly crowned with volcanoes, is present along the coast of British Columbia.

Finally, it should be mentioned that the gradient of the deep-reaching seismic plane is steeper than might be deduced from the curvature of the arc. Possibly the seismic shear-zone with its high gradient is restricted to the substratum whereas originally another shear-zone came into being in the crust and had a lower gradient of some 15 degrees.

I wish to thank my many friends and colleagues of the University of Cambridge —where I gave a lecture based on the present article on 22 November 1945—for their stimulating remarks as well as for their very kind hospitality. I extend the same feelings of gratitude to Professor Arthur Holmes of Edinburgh. Some of the critical and illuminating suggestions he made during our discussion on several problems of geology have been worked up in the present paper.

[1] B. Willis, "Geologic observations in the Philippine archipelago" (*Bull. Nat. Res. Coun., Philippine Islands*, 13 (1937)).

FURTHER NOTES ON THE KIBO INNER CRATER AND GLACIERS OF KILIMANJARO AND MOUNT KENYA

LIEUT.-COMMANDER P. C. SPINK, R.N.V.R.

IN THE *Journal* for May 1944 I gave a short account of two climbs to the Kibo summit, in January and July 1943. On the second climb the Ash Pit was examined and a series of numbered pegs were inserted along the sulphur beds to mark the extent of the active areas.

It is remarkable that from the time of Hans Meyer's first climb of Kilimanjaro in 1889, to as recent a date as 1937, there are no positive references to thermal activity in the inner crater. This was partly due to the small number of exploratory climbs, but also to the greater amounts of ice and snow than exist to-day. The *nieve penitente* formations especially proved a severe handicap to former explorers of Kibo, and Hans Meyer comments upon the difficulties which he and Purtscheller experienced in their attempt to reach the Ash Pit. He writes: "We soon . . . became involved in a chaos of ruts and rents and jagged points, amid which it was next to impossible to find a footing . . . the brittle crust gave way beneath us, and we found ourselves up to the armpits, struggling to extricate ourselves from the jaws of a crevasse."[1] Hans Meyer, on his own admission, never reached the Ash Pit, the presence of which he subsequently admitted that he only suspected. In 1909 Dr. Jaeger suggested that there might be heat in the Ash Pit, and that this would account for the small amount of ice in that area. The credit of the discovery of the Ash Pit really belongs to Dr. R. Reusch, who examined it on 17 July 1927, but reported seeing no signs of volcanic activity. With the rapid retreat of the glaciers in recent years the smaller ice masses and sheets of the crater have decreased or disappeared, and in February 1945, when I made a third ascent, I found that *nieve penitente* formations no longer constitute a serious barrier or handicap.

In his book, 'Kilimandjaro-Flug,' W. Mittelholzer published some very fine aerial views of the Ash Pit, which show a considerable amount of snow lying. In my opinion it would be impossible for a similar amount to lie there to-day, in view of the recent increase of thermal activity.

W. H. Tilman noticed sulphur fumes in 1933, but it was not until July 1942 that unmistakable signs of activity were found and reported in the Press. Since that date several expeditions have confirmed the apparent recrudescence of activity in the crater, notably those of Mr. J. Richard, who has carefully examined the fumarolic activity of the eastern quadrant of the Ash Pit. Although my investigations were carried out independently we have both arrived at similar conclusions concerning the steady increase in the number of active fumaroles.

When the tectonic features of the Kilimanjaro area are considered these

[1] Hans Meyer, 'Across East African glaciers.' English ed. 1891, p. 183.

Phot. 803 Squadron R.N.A.S.

o massif from the S.S.E. Note typical diurnal cloud masses to the west, which are largely onsible for oblique angle of ice-cap

slight signs of reviving activity are not surprising. Professor Gregory points out that "Kilima Njaro itself, the highest of African mountains, is one of a transverse lineal series which runs E. and W., and includes Mount Meru, Mondul, and Essimingor, while Doinyo Ngai, which is the most active volcano along the Rift Valley, is apparently the eastern vent on the same line." [1]

Recent investigations in the Ash Pit of Kibo

On 25 February 1945, when I made a third ascent of Mount Kibo, I found that the numbered wooden pegs in the Ash Pit were still in good condition. I therefore left them in situ. It was immediately apparent that the sulphur beds had increased, particularly the north-west inner bed, the extension being mainly beyond Peg 15, following the inner circle in a north-easterly direction. I put in a series of six new pegs, 7–12, to mark this extension. At the southern end of the bed I put in a new Peg 6 to mark the smaller southward extension from the old Peg 6. The south-west inner circle beds appeared to have increased a little towards the north-west, and I put in a new Peg 2 to mark this. I was once again rather handicapped by mountain sickness and was not able to do as much as I had intended. I was however able to affirm that the fumaroles on the large rock abutment in the Ash Pit were much the same as in 1943, as also was the activity of the vigorous fumaroles in the south-east quadrant. Activity in the outer north-west and south-west beds appeared to be less than in 1943, but the inner crater area had become more yellow during the nineteen months between the two visits.

The most interesting observation, apart from the extension of the north-west quadrant fumaroles, was the presence of several active fumaroles in the north-east quadrant. In 1943 this had appeared to be the only area free from activity. I took a few solfatara gas temperatures, and found that the mean was 180° F.

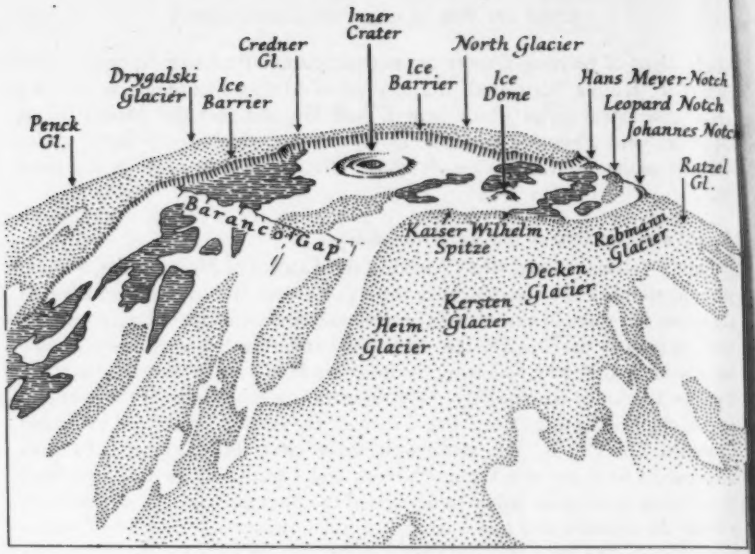
During my 1945 visit the North-East Monsoon was blowing the gases towards my position on the western side of the crater. In July 1943 a north-west wind was blowing the gases away from me and thus the volume on the eastern side was more easily discernible as the gases were streaming up against the dark lava background. Therefore my recent assessment of the areas I was unable to visit may be an understatement of the increase in activity during the past nineteen months. It appears that there has been some increase in activity which is borne out by the extension of the inner north-west and south-west sulphur beds and, most significantly, by the appearance of solfataras in the north-east quadrant which had hitherto appeared quiescent.

The glaciers of Mount Kibo

After examining the Ash Pit I devoted some time to a further study of the unique glaciers on Kibo. I walked up the western side of the crater and obtained a splendid view of the whole Ash Pit area to the east and of the Baranco area to the west. From there I made a westward descent to obtain some idea of the topography of the Baranco, or West Notch, which is bounded on the north-west side by the massive Penck and Drygalski glaciers, the

[1] J. W. Gregory, 'The rift valleys and geology of East Africa,' 1921, p. 103.

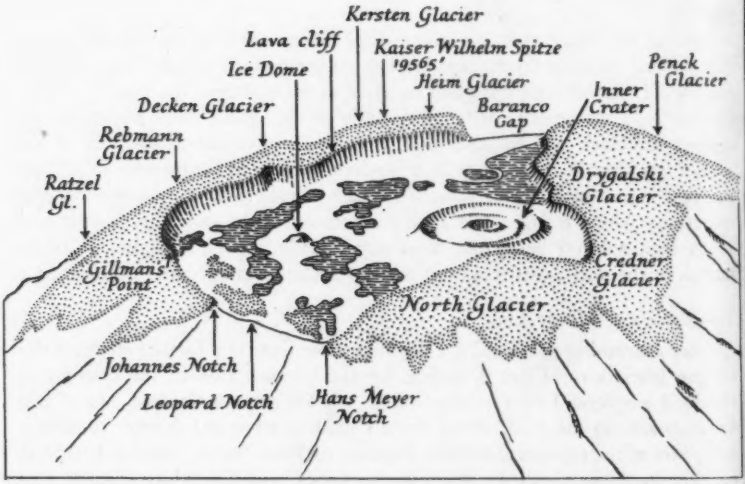
wenzi, 17,400 feet, taken from region of Ratzel
ier. Nieve penitente formations in foreground
Phot. E. Robson, 1943



Glaciers and sheets of ice on Kibo from the south-west

Johannes Notch and Kaiser Wilhelm Spitze are approximately 1 mile from Inner Crater

Glaciers Ice sheets



Glaciers and sheets of ice on Kibo from the north-east

Phot. 803 Squadron R.N.A.S., Tanga.

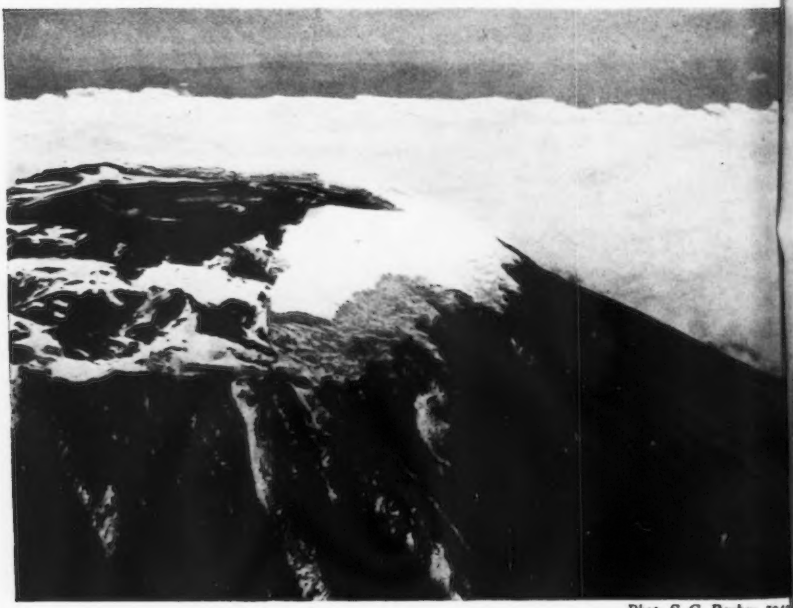
Glacier and sheets of ice on Mount Kibo from the south-west (see key opposite)

Phot. 803 Squadron R.N.A.S., Tanga.

Glaciers and sheets of ice on Mount Kibo from the north-east (see key opposite)

Phot. S. C. Parker, 194

Examples of three types of volcano: Mawenzi, foreground, extinct; Kibo, centre, alive; Meru, background, dying. Taken from the W.S.W.



Phot. S. C. Parker, 194

Kibo: inner crater, looking west. Note erosion of north glacier in foreground

largest on Kibo. Unfortunately rising cumuli spoilt a possible view of Meru. From there I made my way round below Kaiser Wilhelm Spitze to the Ice Dome, and once again I was impressed with the rapidity of its reduction, both in height and in circumference. I had intended to measure the Dome as a future check upon the rate of melting, but since the weather was deteriorating I had to be content instead with a circumferential measurement of the smaller isolated block at the southern foot of the Dome. This proved to be approximately 250 feet, but I noticed that there is a large crack in it which may cause it to split in the near future.

It is unlikely that there are other glaciers of the Kibo type elsewhere in the world. They are unique in being remnants of a once large and unbroken ice-cap which formerly covered Kibo during the last Pluvial period in East Africa. There is evidence that glacier tongues once descended as low as 11,000–12,000 feet above sea-level.

Large areas of this ice-cap survive to-day as isolated blocks of ice on comparatively level ground in the crater, and are consequently exposed to intense vertical insolation. The result is a peculiar weathering, a type of pillar structure predominates and *nieve penitente* formations are to be seen everywhere. Even on the glaciers of the outer slope, the present rate of erosion and ablation of the firn surfaces, particularly of the outer southern hanging glaciers, is very rapid. Ablation has resulted in vertical terraces, and this destruction, which was first noticeable on the eastern end of the firn surface of the Ratzel glacier in 1932, is proceeding apace in a westerly direction. It now affects the whole of the Ratzel and Rebmann glaciers and most of the Decken glacier. It is significant, that of the five large outer glaciers only the two most westerly, the Kersten and the Heim, still retain a relatively intact, smooth firn surface, though I noticed that a group of rocks is now showing through the ice at the eastern end of the Heim glacier. All the other glaciers are heavily weathered and mainly reduced to horizontal and parallel ice steps.

The process of ablation is rapid once it commences and its advance during the past fifteen years has been remarkable. The massive outer glaciers on the eastern and northern sides show its processes at work: aerial photographs reveal a sort of nibbled effect on the outside edges of these glaciers which is caused by ice steps resulting from ablation. Once a flaw occurs in the original intact firn, the surface exposed to the sun is increased over a given area, ablation is rapid, and eventually the lava floor is exposed. When this happens heat radiation from the dark surface is enormous, and the breaking down of the glacier is much accelerated.

Since my first visit in 1943, the rate of regression has been startling. Professor Ahlmann has found that ablation is 30 per cent. greater over ice than snow. This conclusion was reached after work on glaciers in Iceland and Scandinavia, and there is no reason why it should not apply to glaciers at high altitudes. Ahlmann also found that heat convection and its subsidiary effects are the main cause of ablation and that they are more important than evaporation into the atmosphere. On high glaciers radiation would probably play a large part in the process of ablation and evaporation would be considerable in the thin dry atmosphere at 19,000 feet.

Ablation is greatest on the isolated blocks of dead ice in the comparatively

flat caldera. The surface areas of these blocks are large in ratio to the volume of ice, moreover, except for their tops, all the exposed surfaces are ice. It would therefore appear that their dissolution must be rapid, and that within a comparatively few years, provided the present dry cycle continues, the remnants of the inner glaciers of the crater will disappear, to be followed later by the outer hanging glaciers.

If all the glaciers on Kibo suddenly disappeared at the present time it is unlikely that new ice of any consequence would form. Therefore it is most desirable that an annual photographic record is kept of these interesting remnants, and possibly some form of measurement made of isolated ice masses. For example, my measurement of the block to the south of the Dome might be repeated each year. A summary of the glacial history of Kilimanjaro was made by Professor Fritz Jaeger and was continued up to 1935 by the late Dr. W. Geilinger.[1] Since then little interest appears to have been taken in the subject.

The glaciers of Mount Kenya

A safari up the Mackinder Valley of Mount Kenya, in August 1944, enabled me to study the more orthodox hanging and valley glaciers of the high valleys and corries of this beautiful mountain. After a fairly arduous scramble round the base of the main peak, between 14,000 and 16,000 feet, I was able to make a very rough assessment of the ten surviving glaciers.

All the glaciers appear to be live but receding. Comparisons with early photographs reveal substantial retreats, particularly of the Gregory, Krapf, Lewis, and Tyndall glaciers. Many crevasses show slow disintegration, and ablation of the firn surface of the Lewis was noticeable in places. The Tyndall appeared to have split and was not continuous up the steep side of the mountain as previous photographs prove it to have been. The Gregory glacier, on the north side, shows a sharp retreat compared with photographs taken a few years ago, but it is possible that it advances slightly when the sun is south of the equator and the snow is thicker on the northern side.

A few years ago the Skating Lake, at an altitude of 16,000 feet, extended from the snout of a short branch of the Lewis glacier to within a few yards of the Hut, and formed quite a respectable area of skating ice. In 1926, Major Dutton estimated as much as 2^1_4 acres of ice, and the water even flowed beyond the Hut to form a second pool. To-day there is only an insignificant area of broken ice, though it is probable that this also increases when the sun is south of the equator.

The snout of the Lewis glacier had altered considerably from its appearance of a few years ago. Instead of having an unbroken cliff-like front there was a cave on the right side and a large area had collapsed in the centre of the solid wall to the left. The ice-layers appeared contorted as though under great pressure as the mass is squeezed through the rock walls on each side. The bottom three or four feet of ice is composed of a boulder clay mixture of dirt, small rocks, and ice.

[1] W. Geilinger, "The retreat of the Kilimanjaro glaciers," *Tanganyika Notes and Records*, 2 (1936) 7–21.

Kil
ver

Ice
Flu

Phot. E. Robson, 1943

Kibo: nieve penitente in the caldera. Note short shadow of native thrown by vertical sun

Ice block to south of Ice Dome. Height 30 feet, base circumference 250 feet. Fluting due to ablation. December 1944

Phot. P. C. Spink

Kibo: remnants of ice masses in the caldera. Kaizer Wilhelm Spitze on left, Ice Dome in centre. July 1943

Phot. P. C. Spink

Mount Kenya: large ice cave in Krapf glacier. August 1944

The map of Mount Kenya published by Major Dutton [1] after his 1926 visit shows fourteen different glaciers, named and unnamed. The late Professor J. W. Gregory mentions a system of fifteen glaciers at the time of his exploratory visit in 1893. To-day there are but ten. This decrease is not surprising. To quote a passage by Eric Shipton from 'Upon that mountain' (p. 73): "I fancy all the glaciers of Mount Kenya are dying. Indeed it is a mystery how they contrive to maintain themselves on their present meagre diet of snow. Situated directly on the Equator they have no winter in which to recuperate their strength. In the Himalayas, which at their nearest point are a very long way from the tropics [ranging approximately from 28 to 35 degrees N.], isolated peaks of 17,000 feet are not usually festooned with hanging glaciers. The daily cloud cap over Kenya no doubt affords some protection to the ice." Shipton overlooks the fact that condensation of atmospheric water vapour upon the glacier surfaces would contribute a considerable amount towards supplementing the meagre snow supply.

The Mount Kenya glaciers have a very steep gradient, therefore a vertical sun strikes the surface at an oblique angle, and this may account for the fact that the fantastic *nieve penitente* formations, so common on Kibo, are comparatively rare. The Lewis glacier develops them on a small scale at certain times of the year, but this is the exception rather than the rule.

A detailed examination was made of the snout of the small Krapf glacier, which lies on the north side of the mountain and to the west of the Gregory. Several large caves had developed resulting in exposures of yellow kenyte lava. The fresh exposures in the caves must absorb a certain amount of sun's heat and this being radiated into the cavern must increase the rate of melting. Collapsed caves could be seen at one or two points. Just beyond the snout the local ice-smoothed kenyte was bright yellow, showing that it had been recently exposed, with distance from the snout the colour gradually became darker and purplish, thus giving another proof of the retreat of this glacier. Stratification of the snout was pronounced, the ice being in alternate clear and opaque layers. Colours were very beautiful, mainly ultramarine in varying shades.

The ice-caves were extremely interesting as text-book examples of how rocks are scratched by glaciers. In the interior of one particular ice-cavern the ice had extruded over a large rock, forming the roof of the cave. In this beautiful blue roof many small jagged rocks were embedded, turning the whole into an enormous file working under great pressure. The newly exposed rock showed fresh striations from this over-riding mass of ice, and fresh scratches were evident everywhere.

Although the weather at the time was misty with occasional snow showers, the whole ice face was steadily melting. The noon temperature of the ice was 32° F., but the air temperature in the cave was 34° F. On a clear sunny day the melting process would be much accelerated.

It was not easy to assess the weathering of the glaciers on the southern side of the mountain since they were covered with snow or firn. There was however no sign of snow drifts. This is interesting as it bears out the view that strong winds and horizontal blizzards are scarcely known in East African

[1] E. A. T. Dutton, 'Kenya Mountain,' 1929.

mountain zones. Conversations with mountaineers who have ascended Kibo and Kenya tend to confirm this. They agree that deep snowdrifts are rare, and that the strongest winds occur mainly in the summer months from December to March.

This is understandable since insolation is at its height on the mountains during the dry North-East Monsoon regime, and occasional thunderstorms and squalls are likely to occur. It is on record that the Hut by the Lewis glacier, at 16,000 feet, was knocked down during the late twenties, but there is some doubt whether this was due to wind or to encroachment by the glacier. Indeed the absence of winds was remarkable on our recent safari, despite inclement weather. Even at night the camp fire at the head of the Mackinder Valley was scarcely disturbed by the expected katabatic winds from the glaciers just above. This absence of strong upper winds at considerable heights in East Africa is borne out by a recently completed series of upper wind observations up to 30,000 feet, carried out at Mombasa for a period of one complete year. It is safe to conclude that although blizzards may occur on the upper regions of Kenya and Kibo they are much rarer than at corresponding heights in temperate latitudes.

It is apparent that all the glaciers are regressing on the three surviving glaciated peaks in East Africa. On the Kibo summit of Kilimanjaro and on Mount Kenya the retreat is fairly rapid.[1] On Ruwenzori it is slower, but still marked. Kibo now possesses large but dead remnants. On Kenya the glaciers are alive, but shrinking, and are now a mere remnant of the great masses of ice which formerly carved out the magnificent system of radial valleys, such as the Hobley, Mackinder, Gorges, Hausberg, Hinde, Teleki, and Höhnel, each a perfect example of a U-shaped glacially eroded valley.

It has been estimated that formerly the Quaternary glaciers covered an area of 100 square miles and extended as low as 9800 feet on Kenya[2]; their terminal moraines are evident in the giant heather country, just above the bamboo. These glaciers fed wide rivers flowing down into the forested country round the base of the mountain, evidence of which is to be seen in the large alluvial deposits and water-borne boulders lying many feet above the present levels of the surviving streams.

Gregory in 'The rift valleys and geology of East Africa' remarks that one of the striking features of the scenery on Mount Kenya is the contrast between the rounded summits, once smoothed by glaciers, and the jagged crests and rock pinnacles or gendarmes on the ridges that rose above the former ice zone.

It is strongly urged that a photographic record is kept of the retreat of the glaciers on Kenya as well as on Kibo. A series of photographs should be taken from fixed points at approximately the same date each year. The series would be of considerable scientific value.

[1] I have recently received a letter from Raymond Hook of Nanyuki, dated 14 March 1946, who tells me that he has obtained an exact measurement of the retreat of the Darwin glacier on the south-west side of Mount Kenya. This works out at 200 feet in the last 25 years. He also confirms that the Kolbe glacier has totally disappeared.

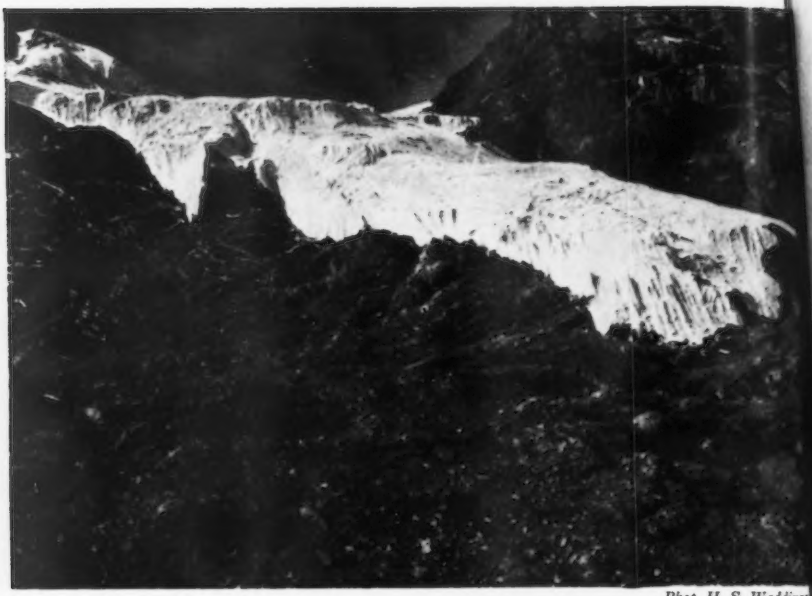
[2] J. W. Gregory, 'The rift valleys and geology of East Africa,' 1921.

Phot. H. S. Waddington

Mount Kenya from the north. Nelion, 17,000 feet, on left, Batian, 17,040 feet on right. Gregory glacier left, Krapf glacier centre, Northey glacier extreme right

Phot. H. S. Waddington

Mackinder valley. Mount Kenya, with senecios in the foreground. Note typical U-shape



Phot. H. S. Waddingt

Mount Kenya: Gregory glacier

Phot. A. P. Da

Mount Kenya: Skating lake and Lewis glacier, February 1945

GEOGRAPHY IN THE SOVIET UNION

The following article is based on a report by Professor Hans W. Ahlmann (in *Ymer* (1945) 241–56) on his experiences as a guest of the Soviet Union at the Jubilee celebrations of the Academy of Science last summer. The original article was kindly translated for us out of the Swedish by Miss M. Burnett of the British Council. Professor Ahlmann informs us that the personalities and the organization of geographical studies have not been changed since his article was written.—*Ed. G.J.*

FROM THE 15th to the 30th of June 1945 the Soviet Union celebrated in Moscow and Leningrad the jubilee of the 220th year of the Academy of Science. It should be realized, if the significance of the jubilee is to be understood, that the Academy of Science in the Soviet Union, which includes both the natural sciences and the humanities, represents something more than a parallel institution in other countries. The Academy was founded by Peter I on the European model. After its removal from Leningrad to Moscow in 1943—a change remarkable and symbolic in itself—decisive measures taken in the highest quarters have brought about a tremendous development, and it has increasingly acquired a special character of its own. According to paragraph 44 in the Rules of the Academy, the Research Institutes are the basis of its activities, and fifty-five such institutes as well as a number of museums, experimental stations, and observatories have now been incorporated.

The latest Research Institutes, established in 1944, are devoted to natural history, forestry, the Russian language, and the history of art. While these institutions enjoy a certain degree of independence they are coordinated by the Academy in a single programme of work. The Academy is also a university with one thousand two hundred students a year, as well as three hundred more advanced students under the direct instruction of the staff of the Institutes. The personnel of the Academy and their families number about ten thousand people. Most of them are provided with accommodation in the vicinity of the Academy and its Institutes.

The Academy of Science is already beyond dispute the centre of all scientific activities in the Soviet Union, and coordinates scientific work throughout the whole country. With the growing importance of Moscow as a centre of influence, the importance of the Academy is likely to increase.

To understand the organization of science within the Soviet Union, and also the cultural position of the Union's republics within the Russian community, it should be noted that the Academy is establishing branches in the various republics. There are now branches in Kazakhstan, Kirgizstan, West Siberia, and Ural. When these branches have grown in extent and influence they will become independent. This has already happened in Georgia (Stalin's homeland), Armenia, Uzbekistan, and Azerbaijan.

After this digression, which seems to me necessary in order to understand the situation with regard to science and research in the Soviet Union, I come to my special subject, physical geography. Physical geography is certainly

not one of the more popular sciences, but there was much to experience and learn, above all about subjects closely related to physical geography.[1]

In Moscow there are two geographical institutes, that of the Academy of Science and that of the University. The last named is under the directorship of Professor A. A. Grigoriev[2] and at present is housed in an old dilapidated building, but is to have new premises as soon as possible. The institute has the following eight departments: (1) Physical geography—director Grigoriev; (2) physical geographical synthesis—Professor Richter; (3) climatology—Professor E. E. Federov; (4) geomorphology—vacant; (5) regional economic geography —Professor Vasutin; (6) cartography—Professor Strelbitski; (7) agro-climatology—founded three years ago—Professor Kolaskov; (8) stereo-photogrammetry—vacant. Publication of the Journal of the University Geographical Institute ceased during the war, and its findings are now printed in the series published by the Academy of Science: *Bulletin de l'Académie des Sciences de l'Union des Républiques Soviétiques Socialistes: Série géographique et géophysique*. Longer geographical works are also published separately by the Academy of Science.

At the exhibition of its most recent work, arranged by the University Institute on the occasion of the jubilee, I noticed the many volumes, still in manuscript for lack of printing facilities, which were the result of exhaustive and systematic geographical research and exploration in the vast regions east of the Caspian sea. Also noticeable was a work, likewise in manuscript, on the formation of ravines and soil erosion on the right bank of the Volga. Research on the subject of Kamchatka in the last glacial period proved that only the inner, higher regions showed mountain glaciation. Professor Obruchev's hypothesis of a continuous ice-sheet covering the greater part of Siberia and neighbouring regions has been shown to be erroneous, as appears also from I. P. Gerasimov's and K. K. Markov's work: 'The Glacial Period in the Territory of the U.S.S.R.' (Moscow: Academy of Science, 1939). Finally, there was the agro-climatological work, including research on ground humidity with the help of what appeared to be a simple and easily mastered electrical method. There seemed to be no research on historical-cultural geography and activity was confined to physical geography, especially in its practical application.

All correspondence and exchange of publications between the University Institute and foreign countries has to take place through the Academy of Science. The latter will also publish the great work in eight volumes, now in preparation, on the geography of Russia.

The Geographical Institute at the University of Leningrad had been damaged by a bomb, so I was not able to see it. According to an account in its journal, during the years immediately preceding the war, it was under the direction of Professor F. A. Matjichin and, like "the geographical faculty,"

[1] A series of writings on various branches of science, including 'The progress of geological and geographical sciences in the U.S.S.R.,' was published for the jubilee. At the opening on June 16, V. A. Obruchev gave a lecture published as "The activity of the Academy of Science in the field of geological and geographical exploration of the Soviet Union."

[2] When it has not been possible to verify the correct English transliteration of Russian names the Swedish form, used by Professor Ahlmann, has been retained.

organized in the following sections: (1) physical geography—Professor A. A. Borsov with three other professors, four lecturers, and three assistants; (2) general geography of lands outside Russia—Professor Dobrinin; (3) general geography—Professor B. P. Orlov, divided into (*a*) general geomorphology—Professor Shchukin, (*b*) meteorology—Professor Sjustov, (*c*) hydrology—Professor Orlov; (4) physical geography of the U.S.S.R. divided into (*a*) Europe—Professor Soloviev, (*b*) Asia and the Caucasus—Professor Shchukin, (*c*) methods of physical geographical research—Professor Gerasimov, (*d*) air survey—Professor Haveman, (*e*) history of geography—Professor Soloviev, (*f*) landscape study—Professor Grigoriev (now Director of the Geographical Institute of the Academy of Science); (5) economic geography of the U.S.S.R. —Professor N. N. Baranski with two other professors, five lecturers, four assistants, and two laboratory assistants; (6) the economic geography of the capitalist states—Professor I. A. Vitver with two other professors; (7) cartography and geodesy—Professor V. A. Kumenetski. Besides this, Professor K. K. Markov, working under section 4, was also the special representative for general geomorphology. In the eleven numbers of the journal of the Institute which were published during the years 1937–40, fifty per cent. of the articles dealt with geomorphological subjects (chiefly coast formations) and twenty-five per cent. dealt with economic geography.

The centre for map production is the Institute of Cartography and Geodesy in Moscow. This institute publishes the large atlases, among them the already well-known international atlases. Among maps on a smaller scale may be mentioned the fine hypsometric map of the European part of the U.S.S.R. with neighbouring districts, on a scale of 1/1½M.

Leningrad still offers more of interest to geographers than Moscow. It is the home of the Geographical Society, the centre for arctic research and the geophysical sciences, and the university has a geographical institute. The Geographical Society's great house was, in June 1945, still being used largely as a military hospital; part of it had been demolished by a shell and the old building was in a very bad state of repair. Nevertheless Leo Berg did everything possible to make visitors welcome, and the Secretary, Professor S. V. Kalesnik,[1] showed me the huge collection of books, among which unfortunately there were no Swedish books later than 1940.

Berg and Kalesnik are also professors of geography at the university, where they work in close association with the geologists, now represented by Professor J. S. Edelstein. The university itself, situated in the Vasili-Ostrov quarter of the city on the right bank of the Neva, was severely damaged during the war, and at the time of the jubilee had only just been reopened after the students themselves had helped to repair rooms and corridors.

The Arctic Institute [2] was founded in 1920 with the primary object of examining the hydrographical, meteorological, and geographical conditions along the northern sea route, or North East Passage. The head of the Institute till 1937 was R. Samoilovich, well known in Scandinavia as, among other

[1] Kalesnik is also editor of the Society's journal *Isvestia de la Société Geographie de l'U.S.S.R.*

[2] A more detailed account of the organization of arctic research in the Soviet Union has been published, together with some miscellaneous information about results obtained, in the Norwegian *Polar-årboken* 1945.

things, the commander of the ice-breaker *Krassin* during the rescue of the survivors of the Italia disaster in 1928. Since 1933 the Arctic Institute, which occupies a private palace at Fontanka 34, has been the scientific centre for the Chief Administration of the Northern Sea Route, founded in the same year in Moscow, and called Glavsevmorput for short. Its present director is Ivan Papanin, famous for his expedition in 1937–38 which drifted on an ice-floe with the East Greenland stream from the region of the North Pole to the regions round Scoresby Sound. The head of the Institute is the young B. H. Buinitski, a former leader of the *Sedov* expedition, 1937–40. The oceanographer and climatologist is still Professor W. J. Wiese, author of a number of important works and a source of great inspiration for all scientific research in the Arctic. The mathematician, Otto J. Schmidt, formerly so active and influential as a member of the Academy, has retired during the past few years.

The scientific activity of the Arctic Institute is singularly comprehensive. Throughout the war seventy-seven hydrological-meteorological stations have been working, each with a staff of four or five men. Besides this, flights are carried out over the sea during the summer months from stations on the mainland, to make maps of ice conditions. With the help of these flights, which recently amounted to about two thousand flying hours a year, monthly maps have been drawn up of the distribution of different forms of sea-ice. As an aid to navigation, monthly forecasts are made of the extent of sea-ice on the basis of barometric pressure.

The present traffic along the northern sea route, which played a particularly important part during the war, has been made possible by the efforts of the Arctic Institute with its stations and forecasts, its radio bearings and its air reconnaissances, and the great ice-breakers. But most important of all have been the greatly improved ice conditions, a result of the recent warming up of the Arctic.

Glavsevmorput, the Chief Administration of the Northern Sea Route, works in close collaboration with several other organizations and institutes. Here I will name only three: the Central Hydrological-Meteorological Office of the Soviet Union in Moscow, under the direction of Eugene Federov, who took part in the Drift Expedition; the Department of Navigation under People's Commissar Peter Shirshov, the third member of the Drift Expedition; and the State Oceanographical Institute in Moscow, under the direction of Professor N. N. Zubov. I would also mention the Academy of Science committee which deals with research on the subject of permanently frozen ground, under the chairmanship of the elder Obruchev.

In this connection one can hardly avoid adding a few words about the Central Geophysical Observatory in Leningrad, which is under the Central Hydrological-Meteorological Office in Moscow, mentioned above. It already possesses, under its chief N. Kandrov, a large house on the outskirts of Leningrad, not far from Professor A. F. Joffe's famous institute, where, incidentally, very valuable investigations were made during the siege of Leningrad into the strength of ice on the routes over the frozen lake Ladoga, the only means of communication between the city and the rest of Russia during this exceedingly dangerous period. The present observatory is already

extensive and has several departments, each under the direction of a professor. One of these professors, a woman, E. Rubinstein, has been engaged during the last few years on an important work on the present changes in climatic conditions, which is to appear shortly in two parts. Plans for development during the next two years are however extensive and illustrate the growth of scientific activity in the Soviet Union. The new observatory will be divided into six departments dealing, among other things, with the physics and mechanics of the atmosphere, including its optics, acoustics, and electrical conditions, as well as their practical importance for flying and radio technique. Special investigations are to be carried out into the heat economy of the strata of air nearest the ground and of the ground surface itself. The climatological department, divided into a theoretical and a practical section, is already far advanced in the preparation of a climatic atlas of the Soviet Union, planned to appear in 1947, with two hundred and forty maps. Meteorology takes a leading place and there is a special department for instruments. With the buildings of the institute, houses for the staff, a hostel for students, a restaurant, and a tower 200 metres high for stationary observations at various heights, the whole establishment forms a small community with several hundred inhabitants.

As another example of the comprehensive studies of scientific problems undertaken in the Soviet Union, it may be mentioned that in the "Report of the Committee on Snow, 1939–40" (*Trans. Amer. Geophys. Union*, Part II, 1940) Professor B. P. Weinberg of the above-mentioned Geophysical Observatory gives a list of six hundred and ninety-four works on snow and ice. Even though only a small percentage of these works may be of any great value, one is compelled to agree with the following views in the *Polar Record* for July 1942 (p. 577):

"It is most unfortunate that this work is largely ignored outside the U.S.S.R. Nearly all the reports are published in Russian, and only a small number appear to be accompanied by brief summaries in English, German and French. In addition to the difficulties of translation, remarkably few of the publications are available in libraries outside the U.S.S.R. To anyone who has attempted to investigate this literature, which is appearing in annually increasing volume, it is clear that little progress will be made in other countries unless translations and summaries are made available, and contact and discussion is developed."

These remarks can be applied to all Russian scientific literature. The Russians are now writing practically entirely in Russian and the summaries in other languages, which one occasionally finds, usually leave much to be desired.

What I have said should be sufficient to show the high standard of scientific work in the Soviet Union, the importance attached to it at the present time, and the intention to improve it both quantitatively and qualitatively. It is therefore not only desirable but necessary that close collaboration should be maintained with the scientists of the Soviet Union, and it is to be hoped that Foreign Commissar Molotov's statement, at the banquet on June 30 last year, will be put into practice: "our efforts are directed to the establishment of good relations between science in our country and science in other parts of the world."

REVIEWS

EUROPE

OUR HERITAGE OF WILD NATURE: a plea for organized nature conservation. By A. G. TANSLEY. *Cambridge: University Press*, 1945. 10×7 *inches;* viii+74 *pages; illustrations.* 7*s* 6*d*

Professor Tansley's book is a plea for organized nature conservation and should be considered in relation to the contemporary report by John Dower on National Parks in England and Wales (Stationery Office, Cmd. 6628), the Report on Nature Conservation prepared by the Ecological Society (Cambridge Univ. Press, 1943), and the reports on Nature Conservation in Great Britain, published by the Nature Reserves Investigation Committee. This book sets out to supply a background of facts and to state the problem, while the writers of the reports go on to propose their solutions.

After defending protective control of the larger mammals the author proceeds with a description of the face of Britain during the Roman occupation, followed by an account of the various types of woodland found in the country. It is interesting to note that pure native ash-woods are so restricted. Later he deals with the need for the expert management of nature reserves, and shows how easily unskilful preservation may lead to the extermination of the species, whose protection was intended. One of the most interesting chapters deals with the work of the Forestry Commission and shows how the planting of exotic conifers in regular rows may be a danger, not only to the indigenous wild life, but also to the natural beauty of rural scenery.

The book hardly pays sufficient attention to drainage operations as a threat to natural vegetation. The lowering of the water-table by the deepening of rivers is likely to produce widespread changes in the distribution of plants.

Professor Tansley's book should be read by all who are concerned with planning or interested in the promotion of nature reserves. Apart from this special interest it has a value as a brief account of our native fauna and flora, and is illustrated by some very charming and beautiful photographs.

A. H. G. A.

ASIA

REPORT OF THE UNITED STATES AGRICULTURAL MISSION to Sa'udi Arabia. By K. S. TWITCHELL, A. L. WATHEN, and J. G. HAMILTON. *Cairo: Misr Press*, 1943. 19×7 *inches;* 147 *pages English text*, 192 *pages Arabic text; sketch-map*

The American Agricultural Mission to Sa'udi Arabia was invited by King 'Abd al-Aziz, and headed by K. S. Twitchell of the Sa'udi Arabia Mining Syndicate. The report contains a great deal of information on Sa'udi Arabia, much of which is of prime importance and almost entirely new to us. It should be read in conjunction with 'Proceedings of the Conference on Middle East Agricultural Development,' Agricultural Report No. 6 of the Middle East Supply Centre (Cairo, 1944), which is concerned with the other countries of the Middle East. A report on the agricultural progress in the Aden Protectorate is also in the course of preparation, and it would be interesting to compare conditions there with those of Sa'udi Arabia, though of course agricultural development in the Protectorate, with the assistance of British technical experts, commenced before the war.

The report is prefaced by a summary of the text by provinces, Nejd, 'Asir, etc. Part I of the report proper covers recommendations and principles to be observed in order to improve and extend agriculture, stock-raising, and irrigation. Part II consists of detailed area reports noting the water resources and land under cultivation or potentially cultivable. Suggestions are also made for appropriate new measures and the extension of existing works.

The authors emphasize the necessity of an irrigation policy to embrace the whole of this vast country. Such a scheme would require much research on climatic and hydrological factors. To put the scheme into effect, Government assistance would be indispensable, and changes in the system of water-rights are suggested. As in the Aden Protectorate, ancient dams have been cleared and repaired, but more can still be done in this direction. In some places malaria control, always closely bound up with irrigation problems, is advocated to open up fresh territory to settlement, as for instance in Jabrin, at present too malarious for further development. Reclamation of land is being successfully undertaken, especially by Ikhwan colonies, a fact already reported by Philby in his earlier books.

Soil fertility improvement and measures to improve stock-raising are discussed, including poultry, a branch in which experiments have also been made in the Aden Protectorate. Cotton it seems is planted in some parts of the country and it may be remarked that the existence of this crop in Arabia is noted by medieval Arab writers. The introduction of apiculture is advised because of the value of bees as pollinating agents. The honey-bee is of course well known in Southern Arabia (*cf.* W. H. Ingrams, 'Report on . . . Hadramaut' (Colonial 123, London, 1937), p. 52 "The Honey Industry," and H. Scott, 'In the High Yemen,' 1942).

Insect pests are noted and methods for their eradication or control are described. Quarantine control of foreign seed entering the country is recommended as a precautionary measure against the introduction of non-native pests.

The authors examine the problem of fuel in its relation to agriculture, a problem vitally affecting the agricultural economy of every Middle Eastern country. To provide fuel and assist in erosion control they advise reafforestation with tamarisk.

Other subjects discussed are finance, land ownership, and the necessity for the construction of good roads when introducing a new economy to the country. There are useful tables of local weights and measures with their western equivalents. There are notes on the oil seep at Jizan, and on the rock salt at Salif formerly worked profitably on behalf of the Ottoman Debt.

It would seem that there is still a good deal of space in Sa'udi Arabia, if progress with agricultural development is made, to meet the increase of population which no doubt will occur in direct ratio to the extension of public health measures and medical aid throughout the country. R. B. S.

CARTOGRAPHY

BRITISH MAPS AND MAP-MAKERS. By EDWARD LYNAM. (Britain in Pictures.) *London: William Collins, 2nd imp.*, 1945. 9×6½ *inches; 48 pages; illustrations and colour plates. 4s 6d*

In recent years there have been numerous studies of the work of individual English map-makers, but a satisfactory historical introduction to the subject has hitherto been lacking. The task of writing such a history within the compass of fifteen thousand words is naturally not without its difficulties particularly to a man of Dr. Lynam's knowledge. Indeed this knowledge appears sometimes to have been an embarrassment, for the text frequently strikes a staccato note,

suggesting that the author compelled himself to break off from one theme and start another lest he became too involved in matters of historical background and cartographic quality. This has the effect of making it difficult for the uninformed reader to discover, for example, in what respects Norden's maps are an improvement on Saxton's, and whether Edward Wright's projection differs from Mercator's. It also explains, no doubt, the absence of any reference to modern cartographers other than the Ordnance Survey.

But it would be churlish to criticize Dr. Lynam when he has given us so much. Not only does he contrive to tell in simple language the story of English cartography from the time of Matthew Paris down to the 5th Edition of the 1-Inch Ordnance Survey Map, but he also traces the main parallel developments in Europe and the mutual indebtedness of English and Continental schools of thought. Further he finds room to speak at some length on the evolution of ornamentation, lettering, and symbolism. There are eight coloured plates and many black-and-white illustrations: these form an integral part of the text and are refreshingly original, some of them appearing in print for the first time. Altogether it is a work of which author and publisher may be proud. In the second impression the several misprints, which occurred in the first, have been corrected. G. H. T. K.

AUSTRALASIA AND PACIFIC

PACIFIC OCEAN HANDBOOK. By ELIOT G. MEARS. (Revised ed.) *Stanford University, Calif.: Delkin*, 1944. 7×4 *inches;* x+198 *pages; illustrations, diagrams, and maps.* $2

This handbook is a summary of the geography, oceanography, and meteorology of the Pacific Ocean, compiled when the first successes against the Japanese were creating a new demand for information. It was intended partly for men serving in the Far East, and contains in appendices practical hints useful to anyone cut off from supplies and transport.

It deals with topography, statistics, climate, sea temperatures, winds, ocean currents, tides, geophysics, geomagnetism, biology, and navigation, and contains much information that has not previously appeared in a book intended for general reference. In covering such a wide range in a small space it cannot help treating some subjects superficially.

It is perhaps misleading in the section on tides to say that there are also tides in the air and the land, without giving some idea of their magnitude, and it would have been useful to mention that in most localities spring tides lag a day or two behind the tide-producing forces, and occur a day or two after full and new moon.

The few misrepresentations that occur seem to be made when the author digresses from his main task. It is unrealistic to describe the Atlantic Ocean as "hemmed-in" by Europe and Africa on the east and the Americas on the west, and the Indian Ocean as "more or less enclosed" by Australia, Southern Asia, and Africa. The warming effect of the Cape Horn current is exaggerated by the statement that it makes possible the world's most southern sheep farm in western South Georgia. Although a few sheep can be fattened during the summer to supply fresh meat to the whalers, they cannot be farmed there; and because of the Weddell Sea current the island is cold for its latitude. There is a confused reference to the currents and tides in the Magellan Strait on p. 28.

The author's emphasis on the protective effect of the mountains along the west coast of the American continent seems very well deserved: they hinder the passage of hot and cold winds in summer and winter, and allow the ocean currents to dominate the coastal region. Describing the Humboldt current region,

the term "Sea Desert" is used in one place because of the absence of rain, and "rich Sea Pastures" in another, because the region is made very fertile by the renewal of plant nutrients in the surface layer by water upwelling from a deeper level. If the description Sea Desert is used, it seems advisable that it should be retained for the subtropical, blue-water, areas in which the plant nutrients are only slowly renewed, and the productivity apparently much reduced.

Much of the book is based on the large geographical works on the Atlantic, Indian, and Pacific Oceans by Professor Schott, and Dr. Mears does geography a service by summarizing and adding to the information on the Pacific Ocean in such a way as to make it available and attractive to more general readers. The book could usefully be amplified, and supplemented by similar accounts of the other oceans. G. E. R. D.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

VOLCANOES AS LANDSCAPE FORMS. By C. A. Cotton. *Christchurch, N.Z.: Whitcombe and Tombs*, 1944. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* x+416 *pages; illustrations and diagrams.* 32*s* 6*d*

In 'Climatic accidents' (1942) Professor Cotton notes the impracticability of his original plan to include all land forms, other than those covered by his book 'Landscape' (1941), in a single volume. Consequently 'Climatic accidents' dealt with arid, sub-arid, and glacial landscapes only. This was fortunate, for the literature of Geomorphology has now been enriched by a separate substantial contribution dealing solely with the other "important accidents" in Geomorphology, as W. M. Davis called them.

How far the author has succeeded in treating volcanic landscapes systematically, and indeed to what extent it is practicable to do so, must be left to the reader to judge. Professor Cotton frankly acknowledges that his arrangement is tentative and experimental. So many factors affect the manner of development of volcanic activity that it may be doubted whether any two volcanoes have precisely similar backgrounds or whether any two are in the same stage of evolution. Are there then adequate data to support the conception of a life-cycle from youth to old age in individual volcanoes or volcanic fields? Should not the life-cycle be sought in a regional history of crustal movement?

The book is divided into two parts. In Part I the author gives a general summary of types of eruption, lava volcanoes, the origin of volcanic heat, gas reactions, pumice (*i.e.* scoria or tuff) volcanoes, and a discussion of Vesuvius and its activity as a mixed lava and pumice vent. The more speculative and controversial problems are fairly summarized. There is a welcome absence of the mass of rock-names familiar to the petrographer, though in later geomorphological portions of the book little-known descriptive terms are freely introduced. This first part is a most useful and well-documented outline of the modern views of volcanicity that can be strongly recommended to the general reader and to the specialist alike.

By far the greater part of our knowledge of the essential processes that control volcanic activity has been obtained during the last two or three decades from scientifically planned investigations of active volcanoes. With continuous observation of critical localities each eruption provides its quota of new data. We may perhaps read into Cotton's most pleasing dedication of his book to Perret and Jagger "volcanologists of this century" a recognition of the youth of the science of Volcanology.

In Part II volcanic landscapes are described. Ten chapters cover constructional forms and the primary destructive explosive and collapse forms such as

maars and calderas. The last two chapters describe systematically the progressive erosion by "normal" processes of plateaux and plains of volcanic accumulation and the destruction of volcanic mountains. The concise and well-illustrated account of constructional landscapes comprises chapters on lava domes, lava fields, the strongly convex forms of viscous outflow such as coulees and cumulodomes or tholoids, nuées ardentes, ash cones, maars and tuff rings, and calderas. The results of submarine volcanic activity are described in a separate chapter.

The broad distinction between fluid basaltic and viscous acid lavas is excellently portrayed in diagrams and photographs: indeed throughout the book a due appreciation of the relation of form to the composition of extruded material is maintained. The reader tends to gain an impression that all acid lavas should show forms indicative of viscosity. The reviewer however recalls a rhyolite flow some 30 feet thick which is mappable for upwards of a mile. The fact that it is an abnormal pyroxene-bearing type suggests that its content of ferrous iron is higher than is usual in rhyolites. If this is so it would support another point stressed by the author—that ferrous iron is of prime importance in promoting fluidity in lavas.

Geologists familiar with the great thicknesses of rock due to volcanic outpourings in past ages and now revealed in section by earth-movement and denudation may feel that the author has in general paid too little attention to the results of detailed mapping of these volcanic piles. The omission of any reference to cone-sheets that are among the most significant results of the mapping of the Tertiary volcanic centres of the Inner Hebrides is a case in point. Again the distinction between the plateau type of eruption and the shield volcano is surely of major significance.

These comments lead naturally to the counter question whether the geologist in studying ancient volcanic remnants has considered adequately the contribution that such dissected remnants might make to volcanology. If there are any weak links in the liaison between those interested in the geomorphological, volcanological, and geological aspects of volcanoes this book should go far to test and reveal them, and it is to be heartily recommended to all who pursue these branches of earth-science whether in research or relaxation. S. E. H.

GENERAL

WEALTH FOR WELFARE. By H. W. Foster and E. V. Bacon. *London: Macmillan*, 1943. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xiv+174 *pages; maps.* 12*s* 6*d*

As much thought is now being given to colonial development, it is appropriate to draw attention to this book. Much of the authors' thesis is in fact generally accepted by those interested in colonial problems.

They insist on the necessity for complete topographical and geological surveys, and a thorough appraisal of the natural and human resources of a colonial territory before any long-term development scheme is planned and launched. The detailed application of their ideas to British Honduras demonstrates effectively the wide scope and possibilities of their proposals. The main problems are to remove the Colony's virtual dependence on one asset, mahogany; to plan the rational use of other natural resources; and to establish a well-balanced agricultural system, which would conserve soil fertility and support peasant settlements in association with light industries. The success of such a scheme would also relieve population pressure in the West Indies. Other examples of maladjustment of population and environment elsewhere in the Colonial Empire are analysed on similar lines and possible remedies suggested.

From these particular instances the authors proceed to discuss in less detail the possibilities of regional cooperation, the advantages of securing the assistance of the Dominions, and the need for a central organization which could make available expert advice wherever required.

The provision of adequate finance is perhaps the crux of their plan. They estimate that their proposals for British Honduras would cost about ten million pounds in the first ten years. The schemes would be carried out by an independent development authority organized on similar lines to the London Passenger Transport Board, in cooperation with the colonial governments concerned.

This book can be recommended as a lucid introduction to many aspects of colonial development. G. R. C.

NARROW-GAUGE RAILWAYS IN NORTH WALES. By C. E. Lee. *London: Railway Publishing Co.*, 1945. 9×6 *inches; 136 pages; illustrations*

This is not an essay in railway geography, but nevertheless it contains much valuable material, culled from many and often obscure sources, which could be used to build up a picture of the economic geography of the North Wales slate industry from 1800 to the present day. Mr. Lee, of the editorial staff of the *Railway Magazine* and *Railway Gazette*, is an acknowledged authority on the early history of railways, and has made a number of special studies of particular lines, mostly the smaller railways which have played important parts in the industrial growth of their districts, or in the history of railway technique and equipment.

The present volume is well printed, with several very clear sketch-maps and a large number of excellent photographs of the rolling stock, stations, and scenery of these interesting narrow-gauge lines.

To North Wales belongs the distinction of being the first area to develop narrow-gauge railways, 2-foot gauge or thereabouts, and also of demonstrating to the world that locomotive traction was practicable on such a narrow gauge. The Penrhyn Railway, built to serve the Bethesda slate quarries, was opened in 1801. It was followed during the next few decades by the Dinorwic slate quarries railroad of 1824, the Nantlle Railway of 3 foot 6 inch gauge (from Nantlle quarries to Caernarvon) in 1828, and the Ffestiniog Railway, from Portmadoc to Ffestiniog, in 1833–36. All these early lines employed horse traction. The first steam locomotives appeared on the 4-foot gauge Padarn Railway in 1848, but it was left to the engineer of the Ffestiniog line, C. E. Spooner, to introduce locomotive traction on the narrow gauge in 1863. This was a pioneer effort of the greatest importance, for no locomotive had yet run on a narrow-gauge line, or on steeply-graded and tortuous tracks such as were to be found on the Welsh slate railways. The instant success of the Fairlie "double-ended" locomotive vindicated the policy, and Mr. Lee suggests that it is probably not too much to say that "Spooner was directly responsible for the general recognition that public steam-operated railways on less-than-Stephenson gauge were a practical proposition." Certainly there followed the widespread adoption of the 2-foot gauge in many parts of India, in the United States, and in other parts of the world.

The next interesting episode is the competition and increased railway building, of standard as well as of narrow gauge, to which the vast expansion of the slate trade in the Victorian period gave rise. Some of the old narrow-gauge tracks were realigned to give easier gradients for the heavier traffic; new narrow-gauge lines appeared, such as the Gorsedda Junction and Portmadoc (1863), the North Wales Narrow Gauge Railway (1877–81), and the Ffestiniog and Blaenau

(1868); while the London and North Western and Great Western companies began to encroach into the slate territory from north and south—the L.N.W.R. with its Bangor and Bethesda line of 1884 and the Llandudno Junction–Blaenau Ffestiniog branch completed in 1879, and the G.W.R. with its Bala–Ffestiniog line in 1882. The spate of house and factory building throughout the country in the last quarter of the century brought great prosperity to the North Wales slate district; but soon after the turn of the century the peak was passed, and mass-produced tiles began to replace slates as roofing material.

There was a revival of railway traffic after the 1914–18 war; the Ffestiniog line made brave efforts to work up a flourishing passenger traffic, and an entirely new line, the Welsh Highland Railway, was built in 1922–23. But the decline of the slate traffic and the loss of passenger traffic to the roads spelt ruin for the Welsh Highland and small profits for the Ffestiniog and others. Activity has been almost at a standstill during the recent war, and the prospects of much revival are perhaps slight, since there seems no reason to suppose that there will be any permanent increase in the quarrying and mining of slates, nor any diminution in the competitive power of road transport for passengers.

Some readers of the *Journal* may be bored by the technical details of locomotives, but the book as a whole is full of interest. For the geographer and economic historian it would have been preferable to have a connected story instead of a series of chapters on the individual railways, but the book was written for those mainly interested in railways as railways and not as factors in the geographical environment and economic life of the area.

Mr. Lee is usually so accurate on technical matters that it is a pity he should have fallen into the common error of referring to the heaps of slate waste as "slag." S. H. B.

BOUNDARY MAKING: a handbook for statesmen, treaty editors and boundary commissioners. By STEPHEN B. JONES. *Washington: Carnegie Endowment Intern. Peace*, 1945. 9½×6½ *inches;* xvi+268 *pages*

Though the literature in English on boundaries is fairly extensive, there is no comprehensive manual on the technique of boundary delimitation and demarcation. Numerous voluminous reports and papers describing the boundary commissions are available but no attempt has so far been made to reduce these to manageable dimensions and to classify the results of field experience. This gap is now adequately filled by Professor Jones's handbook, which makes a timely appearance. Written in a condensed style, well provided with references to British and American sources, it arranges a mass of facts and recommendations clearly and orderly. As a guide to future boundary makers it should prove valuable, and many of its contentions are not aimed at them alone.

Professor Jones recognizes four stages, consecutive and sometimes overlapping, in the process of boundary making: allocation, delimitation, demarcation, and maintenance. Allocation is the task of the highest political levels, and he deals with it only by implication. His constant emphasis on the argument that there is no ideal boundary is directed perhaps to these quarters. No boundary however carefully marked on the ground can completely eliminate the evils of a faulty allocation of territory, and the success or failure of a boundary depends ultimately upon the general political situation between the countries on each side of it, and not upon its strong or weak points as a line upon the ground. It is sometimes implied that with the development of some form of international organization the importance of national boundaries will decrease, but in view of the extent to which the authority of the State in internal affairs has increased of late, this appears unlikely.

After the allocation of the area, the next task is the definition by treaty of the agreed boundary, that is, delimitation. As the author shows, many of the difficulties over boundaries have arisen at this stage. These have two main sources: ignorance on the part of the delimitators of the geographical and human characteristics of the boundary zone, resulting in part perhaps from faulty or inadequate maps, and secondly failure to provide accurate and unambiguous instructions for the demarcation. The author shows how apparently simple terms such as island, channel, and crest, can give rise to subsequent disagreement. The Newfoundland–Labrador boundary case turned largely upon the interpretation of the term "coasts," and perhaps the classic example of a geographical misconception was the definition of a point in the Canada–United States boundary as the "northwesternmost point of the Lake of the Woods," a matter which was not finally cleared up for more than one hundred years. It might appear that a straight line would form the simplest boundary, but in fact it raises problems of its own. The 49th parallel, for example, as now delimited, is neither a geodetic or a consistently astronomical line, but is described as the "mean astronomic parallel," and deviates appreciably from the geodetically determined parallel.

Unsuitable boundaries however result in the main from a failure to understand the character and possibilities of the zone through which the boundary is to run. Where possible the division of a unit such as a drainage basin or the economic hinterland of a town should be avoided, or if a river is chosen as a boundary, its regime should be thoroughly understood, and provision made for any changes which may be anticipated. In dealing with thickly settled regions, the author pleads that modern methods of geographical technique should be available to the delimitators, though he is aware of course that even these can give no absolute and final solution. To avoid future misunderstandings, his recommendations to delimitators include reconnaissance of the region, specification of the maps used in drawing up the text, provision of a glossary of the terms used, the avoidance of too rigid instructions, and power to the demarcators to deviate from the text within specified limits.

The section dealing with demarcation is arranged as a "life history" of a commission in the field, from the assembly and organization of its personnel to the submission of its final report, all of which is supported by copious quotations from the literature.

The Appendices include the "Instructions to Demarcation Commissions, pursuant to the Paris Treaties," and an extensive bibliography, confined however almost entirely to British and American publications. A number of diagrams bring out clearly many of the points discussed in the text. G. R. C.

ADDITIONS TO THE LIBRARY

EUROPE

THE NEW EUROPE; an introduction to its political geography

By Walter Fitzgerald. x+256 pp. Maps. *London: Methuen*, 1945. 14*s*

THE ENGLISH WAY

By Pierre Maillaud. 8×5. 270 pp. *Oxford: Univ. Press*, 1945. 10*s* 6*d*

RIVER FLOW RECORDS. Fifteen years' records of River Moriston at Invermoriston (12 pp.), of R. Garry at Invergarry (20 pp.), of R. Ness at Ness Castle Farm (22 pp.)

By W. N. McClean. 9×6. *London*, 1945

THE GEOLOGY OF THE PRESCELLY HILLS, NORTH PEMBROKESHIRE

By W. D. Evans. (*Q. Journ. Geol. Soc.* 101 (1945) 89–110)

SETTLEMENT PATTERNS IN THE MIDDLE TEIFY VALLEY

By Emrys Jones. (*Geogr.* 30 (1945) 103–11; sketch-maps)

MONTHLY DIGEST OF STATISTICS. Central Statistical Office. No. 1, Jan. 1946, 96 pp.; No. 2, Feb. 1946, 98 pp. 11×8½. *London: H.M. Stationery Office*, 1946. 2*s* 6*d* each number

CATHEDRAL CITY; A PLAN FOR DURHAM

By Thomas Sharp. 9×7. 98 pp. Illustrations and plans. *London: Architectural Press*, 1945. 5*s*

DIE KULTURLANDSCHAFT UND BÄUERLICHE WIRTSCHAFT BEIDERSEITS DES RHEINTALES BEI ST. GOAR

By Leo Aaris (*Acta Geogr., Helsinki*, 9 (1944) No. 1, 106 pp.; sketch-maps and illustrations)

POLAND BETWEEN THE WARS; a critical study of social and economic changes

By Ferdynand Zweig. 8½×5½. 176 pp. *London: Secker and Warburg*, 1945. 10*s* 6*d*

NOTES ON THE GEOLOGY OF THE SOUTHERN RUMANIAN OIL DISTRICT

By J. F. M. de Raaf (*Q. Journ. Geol. Soc.* 101 (1945) 111–34; maps and illustrations)

ASIA

REPORT OF THE UNITED STATES AGRICULTURAL MISSION TO SAUDI ARABIA. [In English and Arabic]

9½×6½. 340 pp. Sketch-maps. *Cairo: Misr Press*, 1943

CHINA CYCLE

By Richard P. Dobson. 8½×5½. vi+218 pp. Illustrations and sketch-map. *London: Macmillan*, 1945. 12*s* 6*d*

Experiences in south-west China in the years before 1939

CHINESE SCIENCE

By Joseph Needham. 8½×5½. 96 pp. Illustrations. *London: Pilot Press*, 1945. 7*s* 6*d*

CHINA, HER LIFE AND PEOPLE

By Mildred Cable and Francesca French. 7½×5. 160 pp. Illustrations and sketch-maps. *London: Univ. of London Press*, 1946. 5*s*

DAS FORMENGEBÄUDE DES NORDÖSTLICHEN ALTAI

By J. G. Granö. (*Publ. Inst. Geogr. Univ. Turkuensis*, 20 (1945) 362 pp.; sketch-maps and illustrations)

THE HYDROGRAPHY OF THE BOSPORUS; an introduction

By Philip Ullyott and Orhan Ilgaz. (*Geogr. Rev.* 36 (1946) 44–66)

AFRICA

STATISTICS ON AFRICAN FORESTS AND WOODS

By J. P. van Aartsen (Repr. fr. *Monthly Crop Report, etc., Internat. Inst. Agric. Rome*, 34 (1943) 68–88)

NIGERIA, GEOLOGY AND MINERAL RESOURCES

By F. Dixey. (*Bull. Imp. Inst.* 43 (1946) 300–16; maps and illustrations)

LE CONGO PHYSIQUE

By Maurice Robert. 2nd ed. 10½×7½. 370 pp. Illustrations and sketch-maps. *Brussels: R. Stoops*, 1942

UGANDA MEMORIES, 1897–1940

By Sir Albert R. Cook. 10×7½. xvi+416 pp. Illustrations and sketch-maps. *Kampala: Uganda Soc.*, 1945. 30*s*

AMERICA

OUTLINES OF THE GEOGRAPHY, LIFE, AND CUSTOMS OF NEWFOUNDLAND–LABRADOR (the eastern part of the Labrador Peninsula). 2 vols. (Repr. fr. *Acta Geogr. Fenniae*)

By V. Tanner. 10×7. Vol. 1, 436 pp.; vol. 2, 437–906 pp. Illustrations and sketch-maps. *Helsingfors*, 1944

SLEEPING ISLAND; . . . travels in the great barren lands of the Canadian North
By P. G. Downes. $8\frac{1}{2} \times 5\frac{1}{2}$. 192 pages. Illustrations and sketch-maps. *London: Herbert Jenkins*, 1945. 15*s*

RECENT CHANGES IN THE CONCENTRATION OF MANUFACTURING. [United States]
By Alfred J. Wright. (*Ann. Assocn. Amer. G.* 35 (1945) 144–66; sketch-map)

OUR PETROLEUM RESOURCES. [United States]
By Wallace E. Pratt. (*Ann. Rept. Smithsonian Inst.* 1944, 297–306)

WEST INDIAN ROYAL COMMISSION REPORT
9×6. xviii+480 pp. Illustrations and maps. *London: H.M. Stationery Office*, 1945. 7*s* 6*d*

INTRODUÇAO À GEOGRAFIA DAS COMMUNIÇACÕES BRASILEIRAS
By Mario Travassos. $9 \times 5\frac{1}{2}$. 208 pp. Sketch-maps. *Rio de Janeiro: J. Olympio*, 1942

BRAZIL. REVIEW OF COMMERCIAL CONDITIONS, Dec. 1944. (Dept. of Overseas Trade.) 8×5. 34 pp. *London: H.M. Stationery Office*, 1945. 6*d*

AMAZONIA BRASILEIRA; exerptos da 'Revista Brasileira de Geografia.'
11×7. 480 pp. Illustrations. *Rio de Janeiro: Inst. Brasileiro de Geografia*, 1944

OESTE; ensaio sobre a grande propriedade pastoril. [Brazil.]
By N. Werneck Sodré. $9 \times 5\frac{1}{2}$. 206 pp. *Rio de Janeiro: J. Olympio*, 1941

AUSTRALIA AND PACIFIC

AUSTRALIA. REVIEW OF COMMERCIAL CONDITIONS, June 1945. (Dept. of Overseas Trade)
By Sir Robert W. Dalton. 8×5. 48 pp. *London: H.M. Stationery Office*, 1945. 1*s*

AUSTRALIA IN EMPIRE AIR TRANSPORT
By W. H. Fysh. (*J.R. Aeronaut. Soc.* 50 (1946) 21–72)

DR. LUDWIG LEICHHARDT'S LETTERS FROM AUSTRALIA, 1842–48
Trsl. by L. L. Politzer. 2nd ed. $8\frac{1}{2} \times 5\frac{1}{2}$. 96 pp. *Melbourne: Pan Publishers*, 1945

EASTER ISLAND
By Alfred Métraux. (*Ann. Rept. Smithsonian Inst.* 1944, 435–52)

DEUBA; study of a Fijian village
By W. R. Geddes. (*J. Polynesian Soc.* 54 (1945) Mem. No. 22, 52 pp.)

BRIDE IN THE SOLOMONS
By Osa Johnson. $8 \times 5\frac{1}{2}$. 224 pp. Illustrations. *London: Harrap*, 1945. 12*s* 6*d*

VOUZA AND THE SOLOMON ISLANDS.
By Hector MacQuarrie. 8×5. 142 pp. Illustrations and sketch-maps. *London: Gollancz*, 1945. 9*s*

ARCTIC AND ANTARCTIC

AN OUTLINE OF THE CANADIAN EASTERN ARCTIC: its geography, peoples and problems
By J. L. Robinson. $10\frac{1}{2} \times 8$. 38 pp. *Ottawa: Bureau of N.W.T. and Yukon Affairs*, 1944

REPORTS and other papers relating to the two voyages of the R.C.M. Police Schooner "St. Roch" through the North West Passage, [1940–44] . . . under the command of Staff-Sergt. H. A. Larsen. $9\frac{1}{2} \times 6\frac{1}{2}$. 96 pp. Illustrations and sketch-maps. *Ottawa*, 1945
Describes the voyage from Vancouver to Sydney, Nova Scotia (1940–42) and that from Dartmouth, N.S., to Vancouver (1944).

REPORT OF THE FIFTH THULE EXPEDITION, 1921–24
By T. Mathiassen (*Danish Expedn. to Arctic North America . . . K. Rasmussen*, vol. 1, No. 1, 1–134; sketch-maps and illustrations)
This summary account, delayed by Rasmussen's death, is intended as an introduction to the full scientific reports in course of publication.

THE PETROGRAPHY OF THE FRANZ JOSEF FJORD REGION, North-east Greenland, in relation to its structure
By N. E. Odell (*Trans. R. Soc. Edinb.* 61 (1942–44) 221–46)

REPORT ON ROCKS FROM WEST ANTARCTICA AND THE SCOTIA ARC
By G. W. Tyrrell. (*Discovery Reports*, 23 (1945) 27–102; sketch-maps and illustrations)

GLACIAL DIVERSION OF DRAINAGE, with special reference to the phenomenon of the "lost gorge"
By O. D. von Engeln. (*Ann. Assocn. Amer. Geographers*, 35 (1945) 79–119; illustrations)

THE TIDES OF THE ATLANTIC OCEAN
By J. Proudman. (*Monthly Notices R. Astron. Soc.* 104 (1944) 244–56)

HISTORICAL GEOGRAPHY

A VOYAGE ROUND THE WORLD WITH CAPT. JAMES COOK IN H.M.S. *Resolution*

By A. Sparrman; introd. and notes by O. Rutter. 12½×7½. 220 pp. Illustrations and map. *London: Golden Cockerel Press*, 1944. £4 4*s*

CHARCOT, NAVIGATEUR POLAIRE

By M. Emmanuel. 7½×4½. 204 pp. *Paris: Editions des Loisirs*, n.d.

COPERNICUS AND HIS WORLD

By H. Kesten. 8½×5½. 408 pp. (*New York pr.*) *London: Secker and Warburg*, 1945. 21*s*

A somewhat discursive biography of Copernicus for the general reader, with chapters on Kepler, Galileo, Newton, and other astronomers.

THE JOURNAL OF CAPT. JAMES COLNETT aboard the *Argonaut* from April 26, 1789 to Nov. 3, 1791

Ed. by F. W. Howey (Publn. Champlain Soc., 26). 9½×6½. xxxii+328 pp. Maps. *Toronto*, 1940

ADVENTURES BY SEA OF EDWARD COXERE

Ed. by E. H. W. Meyerstein. 7½×5. xx+124 pp. *Oxford: Clarendon Press*, 1945

Narrative by a seventeenth-century merchant seaman, later converted to Quakerism.

L'OPERA GEOGRAFIA DI LUCA HOLSTENIO

By R. Almagià. (Studi e testi 102.) 10×7. xii+172 pp. Illustrations. *Città del Vaticano: Bibl. Apostolica Vaticana*, 1942

GENERAL

COMPASS OF THE WORLD; a symposium on political geography

Ed. by H. W. Weigert and V. Stefansson. 8½×5½. xvi+466 pp. *New York: Macmillan Co.*, 1944. 21*s*

PLANNING PROSPECT. ('Survey before plan' series, 1)

By E. G. R. Taylor. 9½×6. 64 pp. *London: Lund Humphries*, 1945. 6*s*

A general introduction to the case for planning, political, economic, and financial, as well as physical, without overlooking the complexity of the problem and the difficulties of foreseeing future developments.

OCEANOGRAPHY FOR METEOROLOGISTS

By H. U. Sverdrup. 9×5½. xvi+246 pp. Maps and diagrams. *London: Allen and Unwin*, 1945. 12*s* 6*d*

FOREIGN MAPS

By E. C. Olson and A. Whitmarsh. 9×5½. 238 pp. Maps and diagrams. *New York: Harper and Brothers*, 1944. 21*s*

An introduction to foreign maps for American students. Analyses content of national surveys, and explains characteristic signs, scales, systems of map references, etc. Short glossaries of the principal languages are included.

[FOUNDATIONS OF CARTOGRAPHICAL KNOWLEDGE: GENERAL SECTION.] *In Russian*

By K. A. Salishchev. 2nd rev. ed. (Institute of Geodesy and Cartography, Moscow.) 8½×5½. 368 pp. Maps. *Moscow*, 1944

CHARLES DARWIN AND THE VOYAGE OF THE BEAGLE

Edited by Nora Barlow. 8½×5½. 280 pp. Illustrations and map. *London: Pilot Press*, 1945. 15*s*

Contains thirty-eight letters, mostly unpublished, written between 1831 and 1839, and extracts from his notebooks.

EAST IS WEST

By Freya Stark. 8×5. xx+218 pp. Illustrations. *London: John Murray*, 1945

THE DISTRIBUTION OF TYPES OF SKIN COLOR

By H. J. Fleure. (*Geogr. Rev.* 35 (1945) 580–95)

THE LOCUST PLAGUE

By B. P. Uvarov. (*Ann. Rept. Smithsonian Inst.* 1944, 331–46)

THE MONTHLY RECORD

PRIZE FOR GEOGRAPHICAL ESSAY

The Council of the Society has decided that the annual Essay Prize, which had been suspended during the war years, should be resumed. The Council offers a prize of £10 for an essay of not more than five thousand words: either a critical survey of recent additions to knowledge in a limited geographical field selected by the writer, or a discussion of some current problem in its geographical aspects. Competitors for the Prize must be registered Internal or External Students reading for Honours in Geography at one of the Universities of Great Britain and Northern Ireland during the academic year within which they submit their Essay. Essays must be submitted during the month of December 1946, the award will be made not later than 31 March 1947, and the Prize Essay will be published in the *Geographical Journal*. Essays in competition for the eighth award of the prize should be addressed to the Secretary of the Society by 31 December 1946.

THE NEW GEOGRAPHICAL RESEARCH SERIES

At a recent meeting of the Council of the Society, it was agreed to inaugurate a new Geographical Research Series of Special Publications. The Council's object is to facilitate the publication of scientific memoirs on any aspect of Geography, too long or too specialized for publication in the *Geographical Journal*. The cost of publication would be met by the Society. Each memoir, in style and format similar to the *Geographical Journal*, would not normally exceed sixty-four pages of print, and allowance has been made in estimating cost for a limited number of plates, maps, and figures in the text. The distribution would be about five hundred copies.

While papers offered for publication are normally expected to be the products of mature scholarship, theses for a doctorate or similar research degree from post-graduate students will also be considered. Papers for this series should be sent to the Secretary, who will submit them for consideration by the Publications Committee.

RECENT GEOGRAPHICAL APPOINTMENTS

In the *Journal* for September–October 1944 we gave details of recent appointments to Chairs of Geography. Since then the following appointments have been announced. Two Professorships are consequent upon the retirement of the holders of the Chairs: Dr. L. Dudley Stamp succeeds Professor Ll. Rodwell Jones at the London School of Economics, and Dr. D. Linton succeeds Professor R. N. Rudmose Brown at Sheffield. Mr. A. C. O'Dell has been appointed Head of the Department of Geography at Aberdeen upon the retirement of Mr. J. McFarlane. Mr. W. G. East, formerly Lecturer in Historical Geography at the London School of Economics, has been appointed to a Readership in Geography at the University of London.

CORAL REEFS AND AIR PHOTOGRAPHY

It is interesting to record not only that the Great Barrier Reef Committee has resumed its meetings, but also that a great increase of field work in the reefs is anticipated. In August 1945 Flight-Lieut. R. W. Fairbridge spoke to the Committee on the importance of aerial survey in the solution of coral reef problems. Our Society has received a typewritten summary of this lecture, and the writer and English members of the Barrier Reef Committee have also had copies.

It is however important that more general attention should be given to the

matter, and this short note is written with that end in view. The Pacific war, like that in Europe, has produced an enormous number of air photographs. Their general use needs no comment here, but it is worth while calling attention to the application of aerial photography to beach landings in order to point out that a similar problem was present in coral reef areas and that in this a great increase in purely scientific knowledge has resulted from their primarily bellicose application. Dr. Fairbridge points out that during the war the greater part of the coastal area of Queensland has been photographed on scales ranging between 1/50,000 and 1/15,000. Certain small districts have been covered on scales of 1/5000 and 1/2000. The coastal photographs also include a fine series of obliques almost from end to end of the Barrier Reefs.

Because of particular landing difficulties on Tarawa, Biak, and Morotai, Dr. Fairbridge recommended selecting certain key places on the Queensland reefs and photographing them from various altitudes and angles. This work was backed up by detailed work on the reefs and islands themselves, and so the photographs could be interpreted with a very high degree of accuracy. Among islands and reefs so investigated were Green Island, near Cairns, Low Isles, the home of the 1928 Expedition, West Hope Island, and Lizard Island. Low Isles was mapped in great detail by Spender in 1928–29: the others were all visited in 1928 or 1936 and of some rough surveys were made and have been published in the Reports of the Great Barrier Reef Committee and also a few in this *Journal*.

There is no need to give details in this note, but Dr. Fairbridge's suggestions deserve careful attention:

Morphological changes in Island Reefs.—This is a matter which emphatically can be advanced rapidly and accurately by air photographs. I know from experience the difficulty of surveying these islets, especially the mangrove areas. Maps such as those made by Spender—whose death all interested in the Barrier Reefs, as well as many others, will deplore—for Low Isles and Three Isles took a great deal of time and could not possibly be made for many islands. But these two maps should prove an admirable basis for tracing later changes, and, as a visit to the R.A.F. station at Medmenham will show, the stage to which photographic interpretation has now reached makes it clear that the changes on a coral island and reef are now all but an open secret.

The influence of wave-patterns on shingle development.—The significance of this is clear and is closely related to problems investigated in this country.

The structure of Platform Reefs.—Little was known of these before the photo survey was made, and landings on them were impossible. Clearly a wide field of inquiry is opened up.

Orientation and origin of Platform Reefs.—Dr. Fairbridge makes certain suggestions about these reefs which will need checking, ". . . the air survey showed that the Admiralty Charts do not show the very striking diagonal orientation of these reefs. Similar reefs are not nearly so developed, if present at all in other barrier reef lagoons. It is postulated that these lines are to be correlated with sickle-shaped or tensional zig-zag and horseshoe-shaped gravity slip faulting during the Pleistocene. It is postulated that the Ice Age reduction in sea-level would cause removal of water-support, which would lead to collapse along the continental margins. This idea may be tested by analysis of soundings, by further bathymetric and surface cartography, and by a number of other means, mainly geophysical."

The writer does not feel competent to comment directly on this matter, but the suggestion that aerial photography and geophysical methods can and should be applied to this type of problem is strongly to be supported.

The morphology of Fringing Reefs.—Dr. Fairbridge quite rightly points out that students of coral reefs have rather neglected the study of fringing reefs and have given perhaps too much attention to atoll and barrier reefs. This is a just criticism, and the relation of fringing reefs to coastal physiography is well worth study in detail. Again, aerial photography associated with detailed ground work in selected localities should go far to define the true nature of the problems to be solved.

Relationship of Fringing Reefs to Littoral Benches.—It was noted during the air survey that there was "a gradation from reefs into benches, suggesting possibilities of correlation and dating, which have hitherto been unsuspected." This is a matter certainly worth further investigation. My own observations made in 1928 and 1936 convinced me that a great deal of work was necessary on the problem of benches, and I am glad that air photography will be of use in its solution.

Mangrove studies.—The mangrove islands are of great interest, and, as Dr. Fairbridge notes, are the meeting place of Botany, Zoology, Geology, Chemistry, and Oceanography. Although a mangrove swamp is a most unpleasant place to work in for more reasons than one, there is nevertheless need for a fuller study. Air photography possesses obvious assets because even in a small swamp it is extremely difficult to move about, and ground survey is usually impossible. Dr. V. J. Chapman's studies in the West Indies (*Geogr. J.* 96 (1940) 312–23) also illustrate the importance and interest of these swamps.

Admiralty charting.—Air reconnaissance has only served to emphasize the poorness of these charts outside the main shipping lanes. It is obvious that a coordination between the work in the air and on the sea is necessary, and should be carried out as soon as possible.

The other points made by Dr. Fairbridge are perhaps not so directly related to air photography. It is clear nevertheless that an adequate series of photographs will be a great asset in arriving at an agreed nomenclature. Personally I still hope that the Admiralty term Great Barrier Reefs will come into general use—even for the name of the Committee sponsoring this excellent work. The plural form is much more accurate and, except perhaps as the title of the Committee, just as euphonious as the singular form.

Apart from the many excellent reasons given in the typewritten notes that have been sent to this country, it may probably be assumed that Dr. Fairbridge and others have extended their studies in the interpretation of air photographs and shown how they may be used in distinguishing between various types of vegetation. This may be of great ecological significance in the various types of islands in Queensland waters. A great deal of the interest of the low wooded islands and cays lies in their beach formations. In 1936 much attention was paid to the mapping of this feature. Air photographs should reveal major changes—if there has been time for them—and also should serve as a valuable check. Again, as in fact is noted by Dr. Fairbridge, details in the water immediately offshore often become extremely clear in air pictures: the need for this information was felt in earlier expeditions, and could only be obtained by elaborate surveys of a particular reef.

The Committee has the best wishes of all who are interested in coral problems in the furtherance of its work. As soon as conditions permit it is to be hoped that another expedition can be arranged. With the new methods of approach and the volumes of the Snellius expedition published during the war now to hand, there is every reason to suppose that such an expedition would be revolutionary.

J. A. STEERS

AERIAL PHOTOGRAPHY

In the House of Commons on Wednesday 10 April 1946 Mr. E. H. Keeling asked the Under Secretary of State for Air whether his attention has been drawn to the Royal Geographical Society's exhibition of R.A.F. photographs, demonstrating the wide application of air photography to civil and scientific uses; and whether he will arrange for the negatives and prints of photographs taken by the R.A.F. during the war to be preserved in good condition until those of value can be selected and placed in a national photographic library, such as that established in Canada. (*Hansard*, Vol. 421, No. 121, 1917–18.)

Mr. Ivor Thomas replied: "My Noble Friend the Secretary of State for Air is grateful to the Royal Geographical Society for the exhibition which they recently held, and he hopes that the wartime developments in aerial photography will be widely extended in future. The R.A.F. wartime photographs are being preserved while the best arrangements for their future use are under review with all concerned."

Mr. Keeling then asked if the hon. Gentleman would give an assurance that these photographs would not be allowed to rot.

Mr. Thomas gave an assurance to that effect.

TABLES FOR USE WITH THE THREE POINT PROBLEM OF RESECTION

From C. E. Tildesley, of the Topographical Surveys branch of the Department of Lands and Forests of British Columbia, we have received a photographic print of some tables with an explanatory text, which he has prepared for use in his department. These deal with a method of assessing the reliance which may be put upon a fixation by the well-known Three Point Problem of resection.

Surveyors all know the impossibility of obtaining a fix from a position which is concyclic with the three distant points. They must also at some time have experienced the uncertainty of a solution to such a problem when the position is near to the circle which is known as the "danger circle" to military surveyors. The present tables have been constructed to provide a guide as to the suitability of the three distant points chosen in any particular case. They are based on a probable error of angular observation of 5″ arc, and of 1 in 5000 for linear distances. Mr. H. L. P. Jolly, of the Ordnance Survey, evolved a formula on which the work is based.

While the tables themselves are clear and simple to use, the solution of a problem entails some eight or nine steps involving the use of a protractor, setting off angles and linear distances to scale, the plotting of a curve, and so on. The method is useful, but it is doubtful whether even professional surveyors would take kindly to this somewhat complicated procedure. The traveller with only a limited knowledge of surveying would certainly prefer to do a quick approximate observation of the two angles from the proposed position, and to do a trial plot with station pointers or a piece of tracing paper.

RECENT DEVELOPMENTS IN THE AUSTRALIAN IRON AND STEEL INDUSTRY

The story of Whyalla, on Spencer Gulf, South Australia, is a remarkable episode in the industrial history of Australia. Some of the details are given in two recent numbers of the *Iron and Coal Trades Review* (30 November 1945, p. 848, and 18 January 1946, p. 123). As long ago as 1889 the Broken Hill Proprietory Company, operators of the silver-lead mines at Broken Hill and of the smelters and refineries at Port Pirie, on the eastern shore of Spencer Gulf,

acquired leases of the iron-ore mountains Iron Knob and Iron Monarch, on the western shore of the Gulf, for the high-grade hematite provided a useful flux in the silver-lead smelting process. But values change, and the iron ore began to be appreciated for itself. A jetty was built at Whyalla, and the shipment of ore to Newcastle (N.S.W.) commenced in 1914—just in time for the 1914–18 war. Some 26,000,000 tons of ore in all have been shipped from Whyalla. More recently, a desire to decentralize Australia's primary iron and steel production, coupled with the easy defensibility of the Spencer Gulf location and the economic feasibility of sending coal to ore as well as ore to coal, led to the suggestion in 1937 to erect blast furnaces at Whyalla. The site for a new harbour and the ironworks was reclaimed from tidal flats, and the furnace was blown in during May 1941. The war of course gave a great impetus to the enterprise, and a shipbuilding yard was added, which has launched eleven vessels since 1940. So Whyalla, on the desert's edge, now has a population of over eight thousand.

Other wartime developments have included an electric steel-melting plant and forge for gun barrels at Port Kembla, and new ferro-alloy plant at Newcastle. The development of the iron-ore field on Cockatoo Island in Yampi Sound is proceeding. This is a low-manganese ore which will be useful for blending with the Whyalla ore; it is estimated that shipments may commence at the end of 1946. S. H. B.

UNIVERSITY NEWS

We have had a number of letters from holders of geographical posts in Universities within the Empire expressing appreciation of the value of the *Geographical Journal* as a means of keeping them in touch with geographical work at home. In order to enhance the value of the *Journal* in this respect we would like to include in the Record from time to time notes from the Departments of Geography giving news of any important administrative reorganization and of any important individual or corporate research or other geographical work carried out under the aegis of the Department. We should not expect to receive such notes more often than once a term and we invite the cooperation of the staffs and heads of Departments of Geography not only in Great Britain and Ireland but also in Universities within the Empire in sending us this information. We need hardly say that similar paragraphs on the organization and progress of geographical studies in foreign Universities would also be very welcome.

RESEARCH FELLOWSHIPS FOR WORK IN THE NORTH AMERICAN ARCTIC

The Arctic Institute of North America is offering two Research Fellowships of $1500 each for scientific work in the North American Arctic and Subarctic during 1946. Research must include field investigations either in Alaska, northern Canada, Labrador, Newfoundland, or Greenland. The Fellowships are open "to anyone who has demonstrated his ability to carry out research work of superior quality in some field of science."

The Fellowships will be awarded on the recommendation of the Board of Governors of the Arctic Institute. Application forms may be obtained from: The Arctic Institute of North America, 805, Sherbrooke Street West, Montreal, Canada.

BRITISH GLACIOLOGICAL SOCIETY

The former "Association for the Study of Snow and Ice" has changed its title and is now known as the "British Glaciological Society." The President of this Society is Mr. Gerald Seligman and the Vice-President Mr. J. M. Wordie.

Membership is open to those who have a genuine interest in snow, ice, or glaciers from any aspect.

By permission of the President and Council the temporary headquarters are at the Royal Geographical Society's House. Meetings for the purpose of reading and discussing papers are held at about three-monthly intervals. Most of the meetings take place at Kensington Gore, and to these Fellows of the Royal Geographical Society are always welcome.

OBITUARY

MICHAEL SPENDER

It was said of Michael Spender that he was too much of an artist to be a great scientist. How far the two are incompatible I am not prepared to say. Their claims certainly conflicted in Spender's career. At the age of eight he started to learn the piano. Within a year he was so advanced that his music mistress had little further to teach him. At Gresham's School his music master, Greatorex, was so impressed with his talent that he urged him to take up music as a profession. However having won an exhibition at Balliol, he decided instead on a scientific career. At first he read physics, then at the end of his first year he changed to engineering. In spite of this, in the remaining two years, he took first-class honours in engineering. But nearly all his friends at Oxford were in the musical world, and it seems that the conflict between his artistic inclinations and his chosen course of study may have been partly responsible for the restlessness which marked his university career. Research in the electrical recording of music might have offered scope for both his main talents had he not discovered, after a year of this work, a distaste for commercial methods. He was to find a full measure of satisfaction in scientific exploration.

Spender's first appearance in this field was with J. A. Steers on the Great Barrier Reef Expedition of 1928–29. There he spent a year making a very detailed survey of a typical island of the Reef, other surveys over a wide area of coral reefs and islands, and a series of accurate tidal observations. On his return from Australia he went to Switzerland to work with the Swiss Federal Survey and to study the latest methods of stereo-photogrammetric survey. He continued his studies under Professor Nörlund, of the Geodetic Institute in Copenhagen. In 1932 he was invited to join Captain Ejnar Mikkelsen's expedition to East Greenland as surveyor. Here he developed new and ingenious methods of exploratory survey which enabled him to make an accurate survey of 120 miles of the Blosseville coast in eleven working days. He then made a fine map of 1000 square miles of Kangerdlugssuak. In 1933 he returned to East Greenland with Knud Rasmussen's expedition. By the extensive use of his short-base method and photogrammetry and with the assistance of air photography he and his assistants mapped the whole of the mountainous area as far as the Ice Cap between Umivik (lat. 64° N.) and Kangerdlugssuak (lat. 68°). So good was this work that a party who travelled 100 miles inland two years later to the Watkins Mountains could find no error in the map or in the determination of heights although the country that they passed through had never been actually visited by the surveyors.

In 1935 Spender went with the Reconnaissance Expedition to Mount Everest to make a stereo-photogrammetric survey of the mountain and a large area of the surrounding country. In 1937 he went with me again, this time to the Shaksgam.

On both these expeditions he entered with great enthusiasm into the spirit of the light expedition, using all his ingenuity to reduce the weight of his survey equipment, denying himself tobacco and other small comforts to cut out the last ounce of unessential personal kit, carrying his full share of weight when necessary, and taking full advantage of every opportunity to widen the scope of his contribution to the work.

In 1938 he took up the post of Research Assistant in Photogrammetry at the Society, which he held until 1939. During this time he was also granted a Leverhulme Fellowship for his studies in photogrammetry.

One of Spender's most outstanding characteristics was his penetrating interest in every detail of his immediate experience. Travelling through Tibet nothing seemed to escape his notice: the flora, the geology, the agriculture, the architecture, the local customs, every aspect of the country and the people received its share of his remarkably well-informed attention. Accompanying him on a simple railway journey in England one had the impression that one was taking an active part in driving the train. His intense interest in the detail of his environment sprang, not from a desire to acquire knowledge for its own sake, but from a strong zest for living. This attitude of mind is supremely valuable in exploration, where it finds unusual scope both for expression and development. In the Karakoram in 1937 five months of intensive survey work, hard living and heavy physical labour left him straining to project the experience still farther into a boundless field. I have rarely seen such reluctance to return to the fleshpots.

Among his wide interests, psychology latterly held a prominent place. This was stimulated by a meeting with Jung in 1937 while the latter was making a tour of India. Later Spender travelled back to Europe on the same ship as the distinguished psychologist, and was fortunate enough to spend much of the time in his company. This contact made a profound impression on Spender. As a student of human nature, it was natural that he should take the keenest interest in sociological problems. His own vivid temperament led him to the conviction that one of the greatest evils of our times was the increasing constriction of the life of most industrial and town workers, which confined their vision to a narrowing sphere, preventing them from mastering the whole of any craft, and removing them farther and farther from reality, and thus from the fundamental basis of human contentment. It was Spender's over-riding desire to contribute in some way to the solution of this great social problem.

His critical intelligence, his habit of giving free expression to his lively imagination, his intolerance of conventional forms made him a most stimulating companion. But these very qualities, combined with a lack of tact, perhaps surprising in one so sensitive, and a quick temper, led to many serious misunderstandings with those who had not had the opportunity or had not troubled to understand his complex nature. This resulted in his making many enemies and roughened the path of many of his undertakings. Some of his acquaintance thought him selfish and overbearing. Superficially perhaps he was both. But below this surface one found a rare gentleness, a sympathetic understanding of people, and a strongly developed power of self-criticism, which was constantly rounding the sharp edges of his character and tempering its defects.

There was no man in whose company I found more pleasure, or with whom I would rather have shared the deep and varied experience of an exploratory journey.

E. E. SHIPTON

MEETINGS: SESSION 1945–46

Second Meeting, 12 November 1945. The President in the Chair

Paper: Summary of glaciological researches, 1918–14. By Professor H. W. Ahlmann

Third Meeting, 19 November 1945. The President in the Chair

Geographical Films: Persia and Afghanistan, with commentary by Mr. C. P. Skrine

Fourth Meeting, 26 November 1945. The President in the Chair

Elections: Lieut. Ronald William Bish, R.A.; Alfred Blundell, M.A., B.C.L.; Ralph Bishop Bradley; Mrs. Alice Georgina Brand; Robert Coleman Burgess, F.S.I., J.P.; Archibald H. Chisholm; Tarak Das Dey, M.A.; George A. Victor Foster, B.SC.; Dr. Sidney Cross Harland, F.R.S.; Miss Nora F. Harris, B.SC.; Alfred Gilliam Hearne; Knox McCheyne Hearne; Lt.-Col. Kenneth Beauchamp Hicks; Major Alliston Arthur Jeacock; Shambhu Dayal Kaushic, B.A.; Henry David King; Raymond William Alfred Knibbs; John Maitland Lindsay; Squadron-Leader the Rev. D. McNeill Livingstone, M.A.; Niyandagala Abraham Liyanage; Capt. Douglas James Lowden, R.E.; Duncan McLeish; Squadron-Leader E. Macro, R.A.F.; Miss Nina Makin; Squadron-Leader Vernon Edwin Mearles, R.A.F.V.R.; Emrys L. Peters; The Rev. Arthur John Potts, C.F.; Lt.-Col. Sir Bernard Reilly, K.C.M.G., C.I.E., O.B.E.; Major J. W. Tayler, R.E.; Edward William Tucker; William John Waterston; Peter Wilkinson; Alexander Wilson; George Edward Wilson; Lieut. Peter J. C. Wyndham; Major Charles William Marr Young; Dr. Bogdan Zaborski

Paper: The geography of the campaign in Eritrea and northern Ethiopia. By General Sir William Platt

Fifth Meeting, 3 December 1945. The President in the Chair

Geographical Films: Australia at war in the Pacific, with commentary by Lord Wakehurst

Sixth Meeting, 10 December 1945. The President in the Chair

Paper: New medium and small scale maps of the Ordnance Survey. By Major-General G. Cheetham

Seventh Meeting, 17 December 1945. The President in the Chair

Elections: Robert Price Abraham; Edward Percy Aldrich-Blake, M.A.; Major Jack Llewelyn Reynolds Baiss, R.E.; Miss Victoria Milicent Cholmondeley; Lt.-Cmdr. James Woore Cortlandt-Simpson, D.S.C., R.N.; Major Kenneth Johnstone Cousland, M.B.E.; The Rev. Matthew Isaac Davies; The Rev. Cecil Joseph William Faulkner; Miss Ethel Elizabeth Faulkner, B.A.; Alan Anthony Erskine Green; Alexander John Haddow, B.SC., M.B.; Mrs. Winefride Hannay; Walter Harland; Thomas Desmond Harmar-Smith; Brian Joseph Hartley, O.B.E.; Thomas William Holiday; Mrs. F. A. Marr; Mrs. Mildred M. Martin-Dellridge; Albert John Read; Dr. Vaughan Powell Rhys, F.R.C.S.; Capt. David Scott, H.L.I.; Lt.-Col. George Ingham Smith, M.SC.; Norman Tebble; Lord Tweedsmuir; Ernest James Dalzell Warrillow; Lieut. Anthony Reginald Whiteley, R.E.; Miss D. L. M. Whitmore; Capt. H. R. Wiltshire

Paper: The Arctic flights of the *Aries*. By Wing-Commander D. C. McKinley

Christmas Lectures. 31 December 1945: Modern maps and how they are made. By Major C. A. Hart, R.E.; 4 January 1946: Early map makers. By Professor E. G. R. Taylor

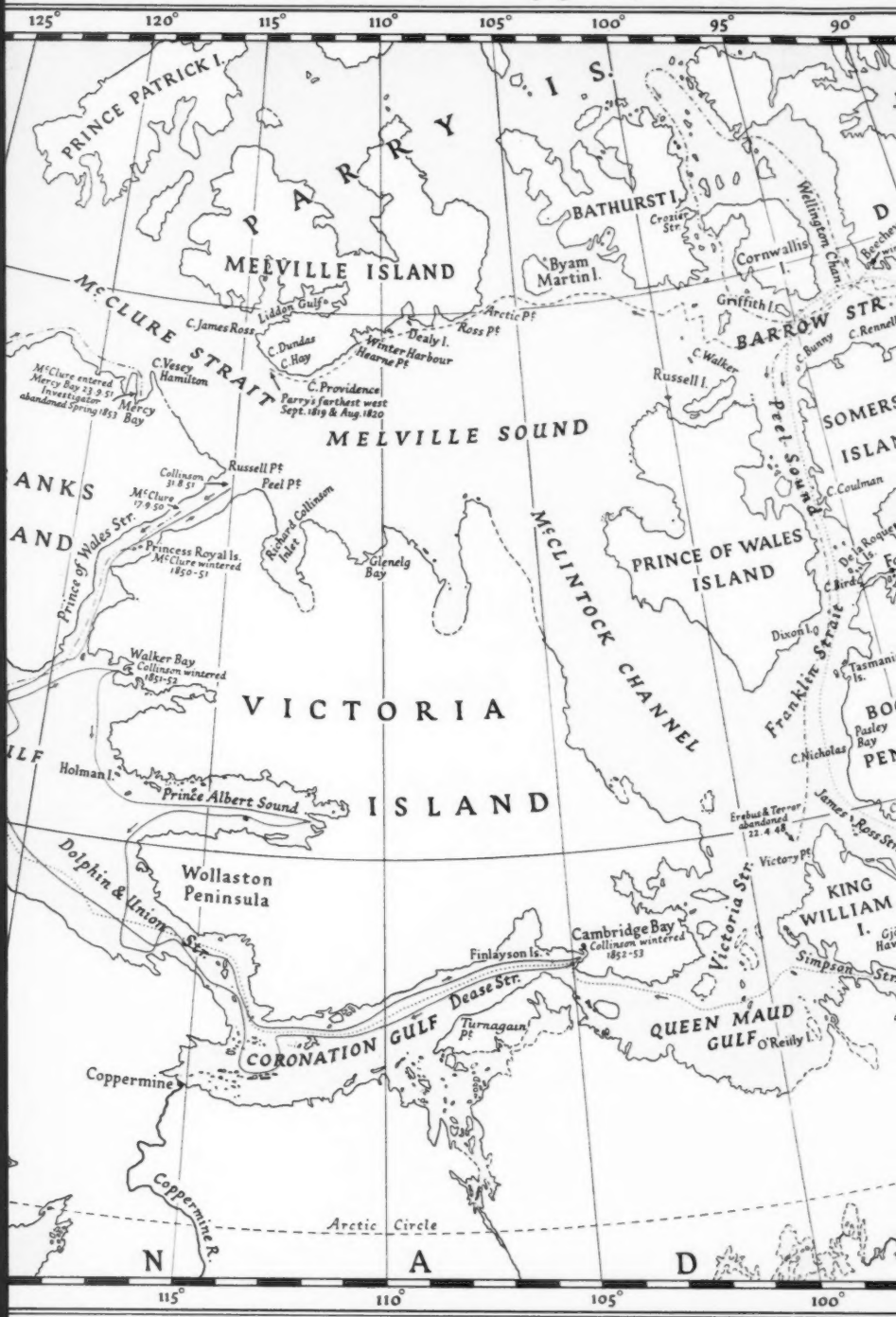
Published May 1946

150°
145°
140°
Miles
50 0 50 100 150
TRACKS
Lieut. W. E. Parry (Hecla & Griper) 1819-20
(outward track only)
Capt. Sir John Franklin (Erebus & Terror) 1845-
Commdr. R. Le M. McClure (Investigator) 1850-
Capt. R. Collinson (Enterprise) 1850-55
Roald Amundsen (Gjöa) 1903-07
BEAU
SEA
McClure
Collinson
Amundsen
Herschel I.
Pelly Is
Toker Pt
King Pt
Amundsen
wintered
1905-06
Mackenzie R.
70°
65°
130°
C

THE NORTH WEST PASSAGE : Map to accompany

Published by the Royal Geographical So

VEST PASSAGE : Map to accompany the papers by R. J. Cyriax and J. M



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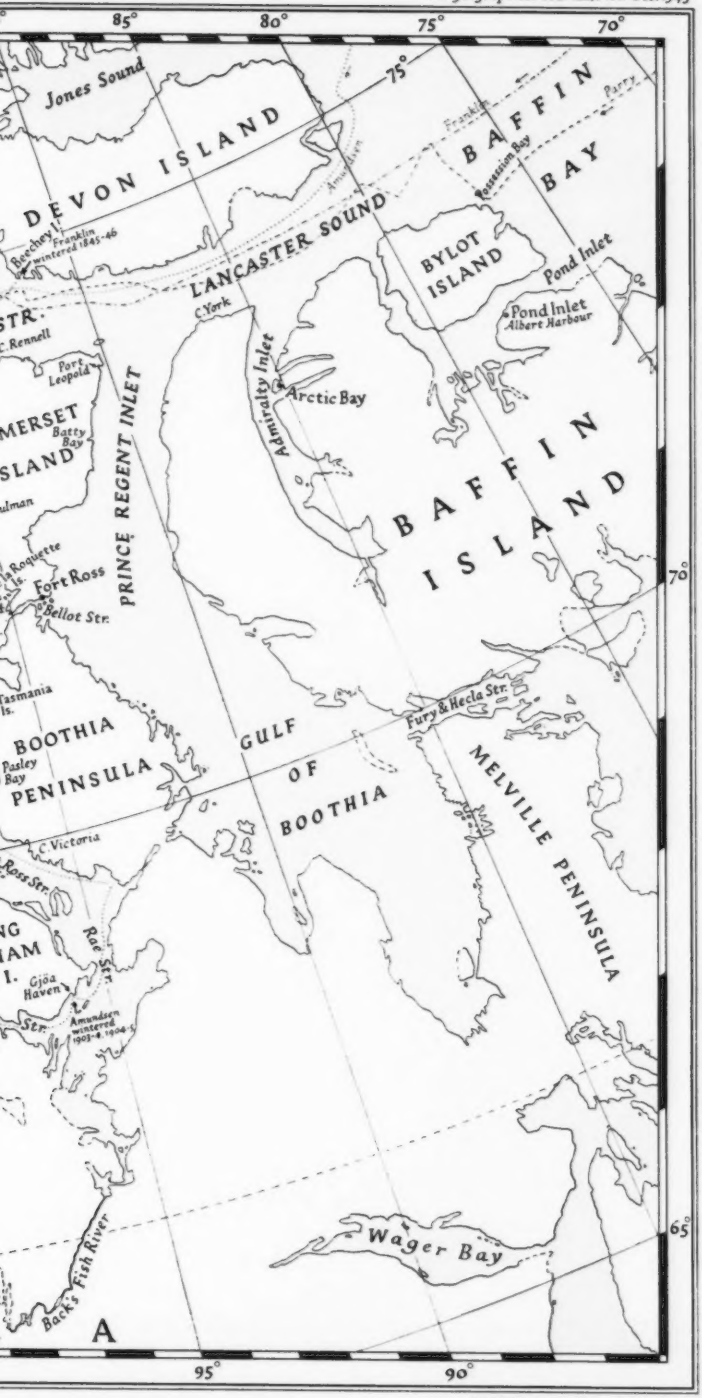
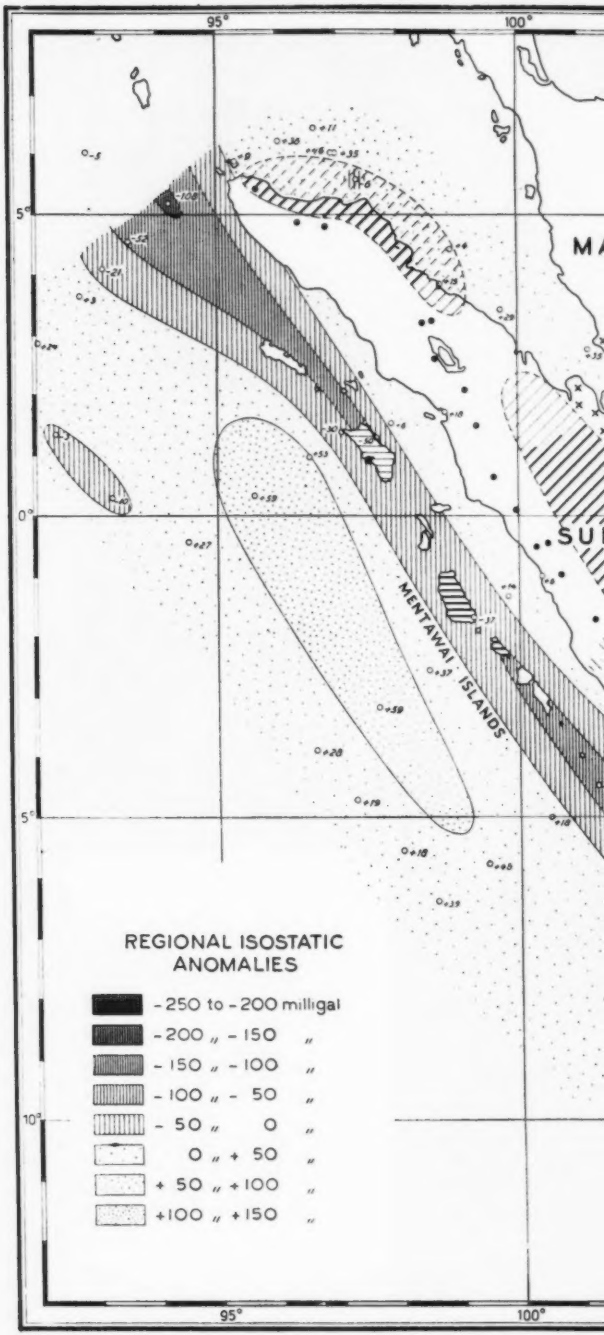


NORTH WEST PASSAGE
Cyriax and Wordie


95°
100°
5°
0°
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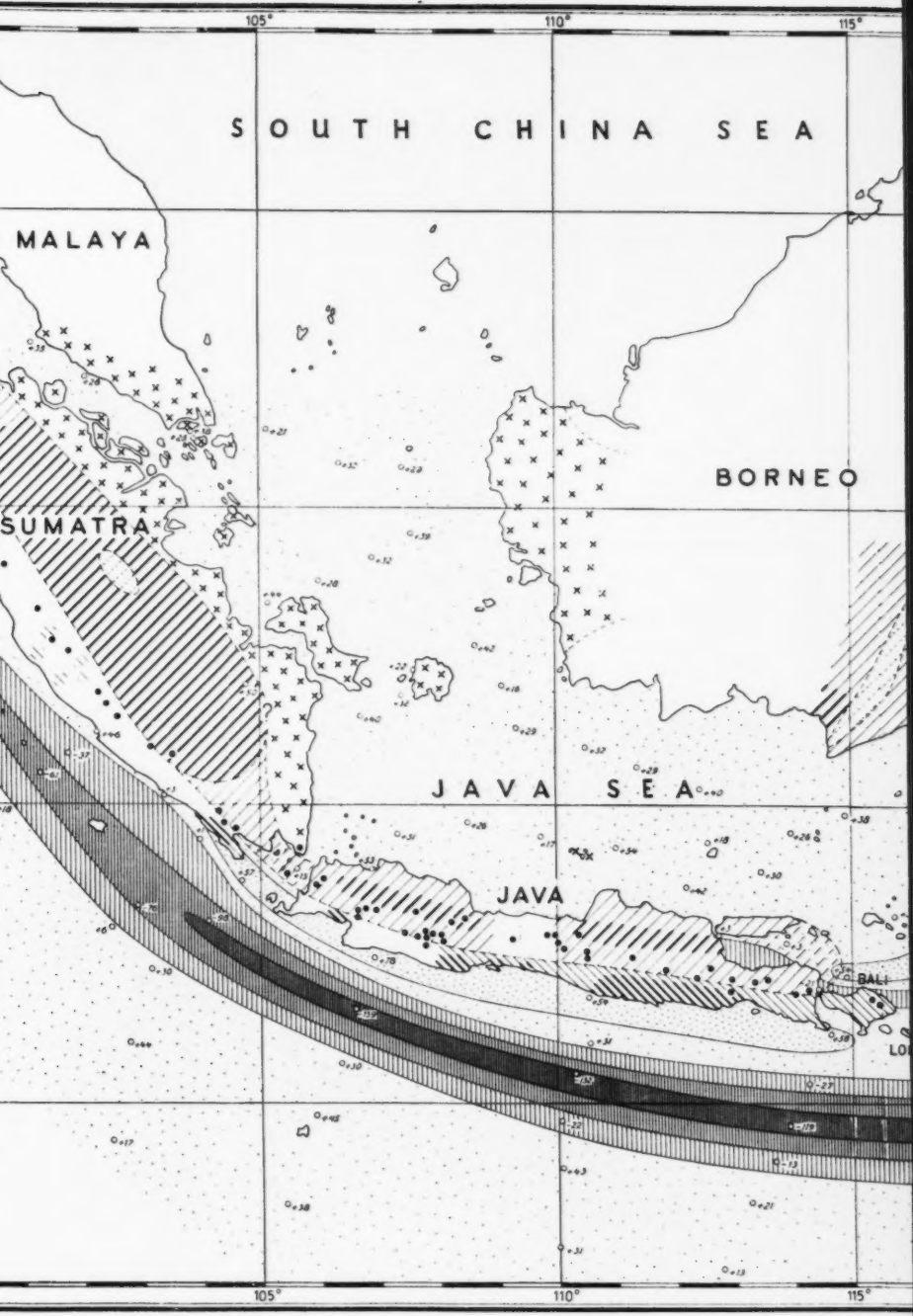
MENTAWAI ISLANDS
REGIONAL ISOSTATIC ANOMALIES
- 250 to - 200 milligal
- 200 „ - 150 „
- 150 „ - 100 „
- 100 „ - 50 „
- 50 „ 0 „
0 „ + 50 „
+ 50 „ +100 „
+100 „ +150 „



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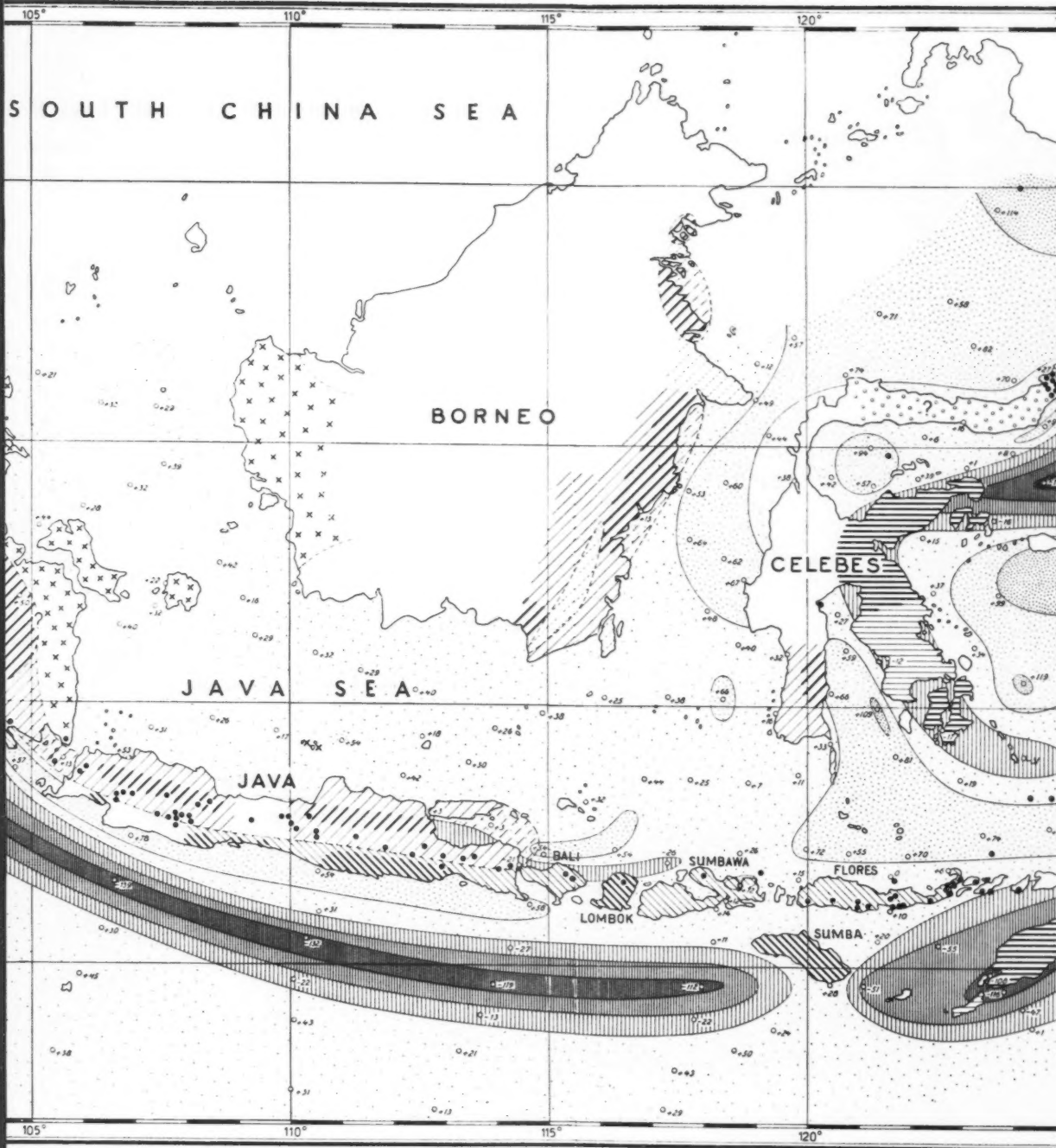

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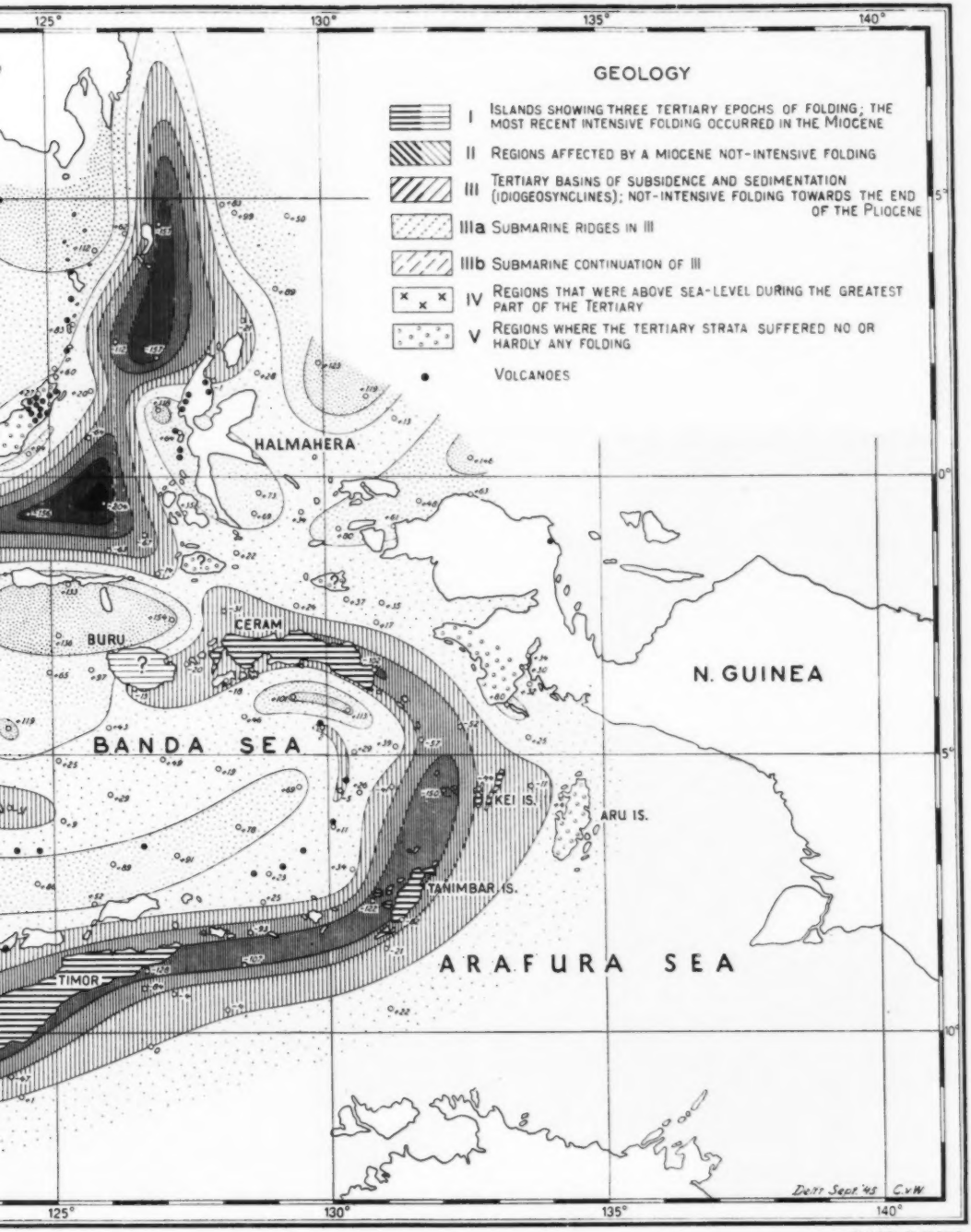

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Umbgrove